Spring Lake

Integrated Aquatic Vegetation Management Plan

King County

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Cover Photos: Spring Lake ca. 1950, taken by George Adams.

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EXECUTIVE SUMMARY

Eurasian watermilfoil (*Myriophyllum spicatum*) is a submersed aquatic noxious weed that proliferates to form dense mats of vegetation in the littoral zone of lakes and reservoirs. It reproduces by fragmentation, and is often spread as fragments that "hitch-hike" on boat trailers from one lake to another. *M. spicatum* can degrade the ecological integrity of a water body in just a few growing seasons. Dense stands of milfoil crowd out native aquatic vegetation, which in turn alters predator-prey relationships among fish and other aquatic animals. *M. spicatum* can also reduce dissolved oxygen – first by inhibiting water mixing in areas where it grows, and then as oxygen is consumed by bacteria during decomposition of dead plant material. Decomposition of *M. spicatum* also adds nutrients to the water that could contribute to increased algal growth and related water quality problems. Further, dense mats of *M. spicatum* can increase the water temperature by absorbing sunlight, create mosquito breeding areas, and negatively affect recreational activities such as swimming, fishing, and boating.

Spring Lake, in the lower Cedar River watershed in King County, Washington, is moderately infested with *M. spicatum*. Members of the Spring Lake Community Club realized the potential gravity of the aquatic weed problem and initiated a partnership with staff from the King County Department of Natural Resources and Parks to apply for an Aquatic Weeds Management Fund grant through the Washington Department of Ecology (Ecology). If awarded, grant money will fund initial eradication efforts, including several years of follow-up survey and control. Since complete eradication is very difficult to achieve, and re-introduction is very likely, the community is organizing a management structure and the funding mechanisms necessary to implement ongoing monitoring and spot control.

Three other noxious weed species with expanding infestations at Spring Lake threaten to degrade the ecological and recreational benefits of the system as well. Fragrant water lily (*Nymphaea odorata*) and purple loosestrife (*Lythrum salicaria*) are rapidly expanding beyond a pioneering level of infestation, and yellow flag iris (*Iris pseudacorus*) is already well established around the shoreline. Immediate control measures are also needed to protect the regionally significant resource areas of Spring Lake and its Class 1 system, Lower Cedar River Wetland 28, from all four of these invasive aquatic noxious weeds.

This *Integrated Aquatic Vegetation Management Plan* (IAVMP), is a planning document developed to ensure that the applicant and the community have considered the best available information about the waterbody and the watershed prior to initiating control efforts. Members of the Spring Lake Community Club and King County staff worked in partnership to develop this IAVMP for Spring Lake. To tackle the difficult task of generating community concern and action for an environmental issue, a core group of residents formed a steering committee, which included two King County staff members. Through their work, the Steering Committee was able to educate the wider community about the problem, inspire them to contribute feedback about potential treatment options, and explore ongoing community-based funding mechanisms. The community ultimately agreed upon an integrated treatment strategy, which includes an initial chemical treatment with a systemic aquatic herbicide, followed by a combination of manual, mechanical, and cultural control methods to maintain the outcome afterwards. This plan presents lake and watershed characteristics, details of the aquatic weed problems at Spring Lake, the process for gaining community involvement, discussion of control alternatives, and recommendations for initial and ongoing control of noxious aquatic weeds threatening Spring Lake.

PROBLEM STATEMENT

Spring Lake is located 6 miles East of Renton on the southern ridge of the Cedar River valley. Lakes Spring, Desire, and Shady are all within the Peterson Creek subbasin of the Cedar River Watershed. King County's Spring Lake / Lake Desire park comprises approximately 373 acres, spanning from the southeastern corner of Lake Desire to the southwest shore of Spring Lake. These lakes drain into the Cedar River and its extremely valuable salmon habitat, and provide Regionally significant wetland and aquatic habitat (King County, 1993). The park bordering Spring Lake includes a rare peat fen and a rocky knoll with montane vegetation. It is a wildlife refuge and popular hiking area. Lakes Desire, Shady, and Spring each have public boat launches and are popular boating, fishing, and swimming destinations. Residents of the Spring Lake watershed are very proud of their setting and are active recreational users. Both the Spring Lake and Lake Desire community clubs are active in social and environmental issues. Nearby Shady Lake recently created its own Lake Utility District to install sewer lines.

Due to prolific growth of several species of dense, invasive aquatic noxious weeds, Spring Lake is in danger of losing its aesthetic beauty, its wildlife habitat, and its recreational attributes. If left untreated, the worst of these weeds, Eurasian water milfoil (*Myriophyllum spicatum*), will blanket the lake in a short time, preventing most recreational uses and eliminating badly needed wildlife habitat. There will be long-term financial and recreational loss and the loss of conservation areas, all affecting watershed residents and other members of the public who use the lake. Increasing development in the area is likely to increase the number of people using the lake in coming years, which accelerates the magnitude of the loss of beneficial uses to the community.

The shallow shoreline area provides an excellent habitat for aquatic plants. In the past few years aggressive, non-native Eurasian water milfoil (milfoil) has invaded the lake and is colonizing much of the near-shore aquatic habitat. The dense submersed growth of milfoil has begun to cause a significant deterioration in the quality of the lake and its value to the community. The boat launch area has dense patches of milfoil, which can spread to other lakes by fragments on boat trailers. Lake Desire and Shady Lake are threatened with new introductions if milfoil if Spring Lake is not controlled because of the high probability of transport by boat trailers to these nearby systems.

Milfoil is the most significant submersed invasive threat but other noxious weeds have also invaded Spring Lake. These include fragrant water lily (*Nymphaea odorata*), purple loosestrife (*Lythrum salicaria*), and yellow flag iris (*Iris pseudacorus*). All of these species are considered noxious weeds as listed in WAC 16-750. None of the native aquatic plants in the system are a management issue at this time. The native plants provide important benefits to the aquatic system and are not impeding any of the recreational uses of the lake. Removing the noxious invaders will halt the degradation of the system and allow the dynamic natural equilibrium to be maintained.

Unfortunately, these invasive plants concentrate in the near shore zone which is also that portion of the lake that is valued and utilized most by lake residents and visitors. Dense weed growth poses a threat to swimmers, and the portion of the lake where people can fish is shrinking. Both milfoil and fragrant water lilies foul fishing gear, motors, and oars. It is no longer possible to troll through large portions of the lake.

As a group these invasive plants:

- Pose a safety hazard to swimmers and boaters by entanglement
- Snag fishing lines and hooks, eventually preventing shoreline fishing
- Crowd out native plants, creating monocultures lacking in biodiversity
- Significantly reduce fish and wildlife habitat, thereby weakening the local ecosystem as well as degrading wildlife and wildlife viewing opportunities
- Pose a threat to adjoining ecosystems

The Spring Lake community has documented three decades of neighborhood funded efforts to control invasive weeds. They have not been able to meet the current challenge of controlling such widespread infestations or of preventing re-infestation. Immediate action is necessary to control Eurasian water milfoil and other invasive weeds. If left unchecked, the lake will soon become heavily infested with aquatic weeds, severely degrading the lake ecosystem and making them even harder to eradicate. The community recognizes that after initial control efforts, opportunity for re-infestation must be prevented.

MANAGEMENT GOALS

The overarching management goal is to control noxious aquatic weeds in Spring Lake in a manner that allows sustainable native plant and animal communities to thrive, maintains acceptable water quality conditions, and facilitates recreational enjoyment of the lake.

There are four main strategies to ensure success in meeting this goal:

1. Involve the community in each phase of management process;
2. Use the best available science to identify and understand likely effects of management actions on aquatic and terrestrial ecosystems prior to implementation;
3. Review the effectiveness of management actions;
4. Adjust the management strategy as necessary to achieve the overall goal.

Specific details related to the implementation of management objectives are covered in subsequent sections of this plan.

COMMUNITY INVOLVEMENT

From the very beginning, members of the Spring Lake community have demonstrated their commitment to improving their community and protecting the lake as well as the expansive natural areas around their homes. This section provides an overview of past, present, and future of community involvement.

Community History

Albert Spring purchased a logged Weyerhaeuser parcel that surrounded the lake, renamed the natural lake from Otter Lake to Spring Lake, and in 1949 began selling the Spring Lake Community. The first year-round residents settled in the early 1950s, and today there are 110 residences on the lake, 245 within its watershed.

From their earliest days, members of the Spring Lake community have worked together to promote common goals, including the health of the lake. During the 1960s the Spring Lake Community Club formed to petition the Washington State Utilities and Transportation Commission for improved telephone service.

One of the Club's largest challenges came in the 1960s, when they fought development plans that included dredging the wetlands to build nine hundred home sites with golf course and pools, as well as a 500-acre mall. Spring Lake residents initiated that legal battle which ended with SEC injunctions against the development firm.

In 1978 lakefront property owners contracted with A & T Weed Service of Tacoma for control of noxious aquatic weeds. In the late 1980s Spring Lake residents were active in petitioning for inclusion of the south shore in King County's Open Space purchases. They also collected neighborhood recycling to document and demonstrate need for county pick-up. In 1989 lakefront property owners hired Allied Aquatics of Washington, Inc. to manage further aquatic plant problems. In both of the prior aquatic weed control efforts, Eurasian watermilfoil was the targeted species.

The membership of today's Spring Lake Community Club reflects the strength of new perspectives and energies. As properties change hands, and the last developable lots sprout homes, new families on the lake join children and grandchildren of the original owners. All share a love of this unique ecosystem, and are committed to honor and perpetuate the legacy of good stewardship.

Community commitment

Throughout its history, the Spring Lake community has demonstrated its commitment to preserving the health and recreational quality of the lake. As mentioned above, available records show the community has funded milfoil removal projects on Spring Lake at least two times in the past (See Appendix A). Families living around the lake paid for those efforts. Today's active Spring Lake Community Club works to unite the neighborhood and inform residents of environmental and safety hazards regarding the lake.

Examples of issues discussed by the Community Club in recent years include:

- The impact of letting purple loosestrife (*Lythrum salicaria*) continue to grow
- How to eradicate purple loosestrife
- What to do about yellow iris (*Iris pseudacorus*)
- How phosphates and other nonpoint source runoff affects water quality
- Problems posed by fragrant water lilies (*Nymphaea odorata*)

Community members have participated in King County's Volunteer Lake Monitoring program since its inception. Currently, three members of the Community Club are volunteer monitors participating in the King County Lake Stewardship program. Lake Stewardship program volunteers monitor lake level and precipitation daily, Secchi transparency, water temperature, algae and bird observations weekly, and collect water samples every other week from April through October. Water samples are analyzed for total phosphorus, total nitrogen, chlorophyll *a* (an analog for phytoplankton concentration) and concentrations of phytoplankton species. Volunteer data are published each year in reports produced by the King County Lake Stewardship program.

In the spring of 2001, the Spring Lake Community Club responded to the over population of Canada geese on the lake. There were 32 resident Canada geese on the 69-acre lake, causing approximately 96 pounds of waste per day to be deposited in and around the lakeshore (Seattle Parks & Recreation, 2002). Out of concern for the health of the lake, the Washington State Department of Fish & Wildlife was contacted. Details of the operation to remove the geese were discussed at a community club meeting and funding was approved. Coordination among shoreline owners resulted in the capture of 27 geese and their removal from the Spring Lake area. The goose population has not returned, except for brief stays, and no further removal has been necessary to date.

The community regularly organizes work parties to control purple loosestrife and yellow iris. The lake community has a history of homes staying within family ownership, and of children returning to build or purchase a house near the one in which they grew up. This is further evidence of the community's intent to preserve the integrity of the unique Spring Lake ecosystem for generations to come. Based on past involvement, and the legacy of families staying within the community, it is anticipated that shoreline residents will be willing to contribute directly to lake-related maintenance activities.

If a new infestation of milfoil or other noxious weeds develops after the anticipated control work, the Community Club will act as a forum to determine what further work needs to be done and how to fund it. Annual dues and assessments have been used in the past and no one has objected to the idea of community based funding. If it became a major issue (i.e., very costly), the Community Club would explore taking steps to form a

Lake Management District to ensure further support for ongoing water quality maintenance and aquatic weed control efforts at Spring Lake.

The success of noxious weed control efforts at Spring Lake rely, in the long run, on providing a funding mechanism for monitoring the success of control measures, surveying for noxious weed species each year, and responding to new infestations quickly to maintain a weed-free lake. The Spring Lake Community Club is exploring ways to provide maintenance funding in perpetuity. Community members are currently discussing several funding ideas. The best long-term solution will inevitably utilize multiple mechanisms. Possible strategies include:

1. Using a portion of the club treasury ($800) to start an endowment. Continued contribution to the endowment could be supported by a $10 - $15 increase in annual Community club dues. The endowment and dues would be dedicated to creating a Noxious Weed Management Fund. Based on current club membership, this would result in a $3800 fund to initiate eradication maintenance after five years, and return approximately $600 per year thereafter.

2. Lake Management District formation. Forming an LMD would levy a “tax” on all property owners within the watershed. The tax paid by each property owner would be determined by the size of the property and proximity to the lake. Funds collected would be used to address specific problems at the lake. In order to form an LMD, watershed property owners need to vote to approve it, and the governing agency (King County) needs to adopt an ordinance recognizing the fee collection structure, problems to be addressed, and the methods by which problems will be addressed.

3. A donation-based fund. This would involve collecting money through fundraising activities, as well as door to door campaigning. Although less consistent, this type of activity is expected to work because of the stability of the neighborhood. Many people are second generation residents and have actively participated in protecting the local environment.

4. Volunteer maintenance: Train residents to perform the monitoring and removal efforts. There are 10 certified divers on the lake. Funds would be collected by the Community Club to purchase necessary equipment and obtain training to conduct the milfoil removal operations by volunteers after the grant funds expire. Currently, lake residents perform invasive weed control efforts voluntarily on the emergent plants at Spring Lake.

Steering Committee, outreach, and education process

Community participation has been an integral part of the development of the Spring Lake IAVMP. Community involvement educates community members about the potential problems posed by noxious aquatic weeds. Since watershed residents were given ample opportunity to comment throughout the process, there should be greater community support for implementation efforts. Documents used to guide the outreach and education process are contained in Appendix B. Meeting agendas, attendance lists, and meeting notes are contained in a separate document entitled *Spring Lake Public Involvement and Meeting Summaries*.

The remainder of this section provides a chronological overview of the community involvement process from the first discussions through the completion of the IAVMP.

Early Discussion: Explored potential for King County-Spring Lake partnership

Ted Barnes, current president of the Spring Lake Community Club contacted King County Department of Natural Resources and Parks (KC DNRP) Lake Stewardship Program staff in the fall 2001. Ted wanted to apply to the Washington State Department of Ecology (Ecology) Aquatic Weed Management Fund for money to help with Spring Lake weed control efforts in summer of 2002. Given the amount of work required to develop an IAVMP, which is necessary prior to application, Ted Barnes and King County staff decided to resume the discussion in spring 2002 to work toward a grant application to Ecology in fall 2002.

June 2002: First meeting with Spring Lake Community Club

Ted Barnes invited King County Lake Stewardship Program and King County Noxious Weed Control Program staff to a Spring Lake Community Club meeting on June 27, 2002. Ted Barnes and King County staff discussed the process by which the community could work with King County to submit an application for funds to control noxious aquatic weeds in Spring Lake. Ted emailed all members of the Community Club and made phone calls to recruit as many members as possible. Twenty-seven people attended the meeting. The primary purpose was to discuss the problem with Eurasian watermilfoil and other aquatic noxious weeds and to learn about the application/ IAVMP development process. A second motive was to assess community interest in moving forward. That evening 12 residents committed themselves to continued involvement in the project through working as a Steering Committee.

July 2002: Project planning begins, Steering Committee meets, begins IAVMP development

KC DNRP staff developed drafts of a project timeline and education and outreach plan (See Appendix B), and began to research necessary components of the IAVMP.

July 17 was the first meeting for the potential Steering Committee members. The primary goal was to formally approve the project Steering Committee, outline necessary tasks for the grant application process, and assign tasks to each Steering Committee member. At this meeting, attendees formally recognized themselves as a Steering Committee to guide the application process, and steering committee members reviewed and approved the proposed IAVMP/grant application timeline and an outreach plan. Tasks were assigned.

August 2002: Steering committee continues IAVMP work, hosts first watershed-wide meeting

In August, steering committee members continued work on the IAVMP and prepared for the first watershed-wide public meeting on August 22. Much of the committee's work occurred in meetings, although email exchanges were also productive. Key achievements in August included a flyer sent to all watershed residents asking them to attend a watershed-wide community meeting; continued work on the draft problem statement; Steering Committee review of available treatment options (adapted from Ecology's website); and community "canvassing" to inform people about the August 22 meeting.

Thirty-eight people attended the Watershed-wide public meeting on August 22. Most in attendance were watershed residents, although there was also a representative from the Cedar River Council. Scientists from the Washington Department of Fish and Wildlife (WDFW), the U.S. Fish and Wildlife Service, and the Department of Ecology were invited to the meeting, but could not attend. King County Council member David Irons was also invited, but did not attend.

At the August 22 meeting, steering committee members presented the problems posed by noxious aquatic weeds, a detailed description of Eurasian watermilfoil and the three other noxious weeds, and reviewed all possible treatment options. In general, community members agreed there was a problem and that the project should continue. Further details of public comment are provided in the Public comment section later in this document.

September 2002: Additional IAVMP work. 2nd Watershed-wide meeting, letter of support circulated

The steering committee continued to research elements of the IAVMP and reach out to community members through phone calls, emails, and personal communications. At a meeting on September 10, the steering committee reviewed comments and content of the August 22 public meeting and all agreed that the wider community expressed agreement that milfoil posed a threat and that action should be taken to eradicate it. Tricia Shoblom from the Washington State Department of Ecology attended the meeting to offer her expertise and provide feedback as to the progress the community had made thus far.

At the September 10th meeting the steering committee developed a control strategy to present to the wider community at the second watershed-wide meeting to be held on September 19. Staff at King County distributed a flyer to all watershed residents to announce the September 19 Watershed-wide meeting.

About 50 community members attended the September 19 watershed-wide public meeting. At that meeting, steering committee members reviewed the problem of noxious aquatic weeds, the results of the steering committee's work, and the process ahead. King County Staff detailed the proposed treatment strategy and cost estimates. After the formal presentation, there was general agreement among all that milfoil and the other noxious weeds present a threat to the lake, and treatment must be a priority. There was discussion about which costs the community would cover and how to raise money to cover those costs. Further details of the public comment are provided below.

At the end of the meeting Steering Committee members read a copy of the Letter of Support and circulated it amongst community members for their signatures. Several people took copies of the letter and signature sheets so that others unable to attend the meeting could sign the letter.

October 2002, Continued IAVMP work, circulation of Letter of Support

Steering committee members and King County staff continued to work on the IAVMP. Spring Lake Residents continued to circulate the letter of support among their neighbors.

The final draft of the IAVMP was issued to Ecology on October 18, and the grant application was mailed to Ecology on October 29.

Public comment

At each of the watershed-wide public meetings, presenters encouraged attendees to ask questions and offer comments.

At the first Watershed-wide meeting on August 22, most comments supported acting as quickly as possible to control weeds in the lake. There were questions about the effectiveness of various treatment options presented. Several comments expressed concern that the community members would need to "foot the bill" for control costs. Steering Committee members addressed concerns when possible, and if answers were not readily apparent, offered to do more research and report back at the September 19 public meeting.

After the presentation of the proposed milfoil control strategy at the September 19 public meeting, Steering Committee members encouraged discussion about the plan. There was general agreement among all present that the proposed management plan made sense, and that managing milfoil would be a community priority. There were several questions about community-based funding mechanisms. Michael Murphy, King County staff member on the steering committee, explained the concept of a Lake Management District to the audience. Another Steering Committee member offered the idea of purchasing a bond, so earned interest could be used for ongoing lake management. Ted Barnes, Spring Lake Community Club President, proposed the concept of setting aside one third ($800) of the current treasury and increasing Club dues by $10 (attendees suggested more) annually and using the extra revenue to fund lake management. While meeting attendees did not reach an agreement on a single community-based fund-raising strategy, all were in agreement that the community should cover costs of ongoing weed management after initial control efforts.

At the meeting in September, Steering Committee members presented anonymous comment forms, in case any community members wanted to offer comments that might be construed as "unpopular" among those present at the meeting. No one offered any anonymous comments. Complete notes from all steering committee meetings and watershed-wide public meetings are in a separate document entitled *Spring Lake Public Involvement and Meeting Summaries*.

Public consensus

Members of the steering committee drafted a "Letter of Support" that members of the community could sign to demonstrate their support of the proposed milfoil control strategy while recognizing its potential cost. To date, there have been no objections to the proposed project or for the proposed methods of treatment. Every person who has learned about the project has voiced support.

Given the community's small size, and their dedication and enthusiasm for keeping Spring Lake healthy, none of the steering committee members anticipate resistance to the proposed project prior to, during, or after implementation. The letter of support and copies of the signature sheets are in Appendix C.

Continuing Community Education

The Spring Lake Community Club will offer the means by which the community will organize ongoing education. In addition, the Steering Committee for the proposed aquatic weed removal project will remain intact, although membership on the steering committee is likely to change over time.

To ensure that community efforts are consistent with best available science and water quality standards, the community club will designate a point of contact liaison within the KC Dept of Natural Resources and Parks. Information will be disseminated through community club meetings, watershed mailings when applicable, and revival of the community club newsletter. A liaison with school and youth organizations will also be designated. Additionally, the community club will work to recruit new lake monitors and surveyors. A community website was developed in September 2002: (http://www.springlakeclub.com). All of the documents and PowerPoint presentations generated by the Watershed-wide and Steering Committee meetings are available for download. Links are provided to the websites for the Washington State Department of Ecology, the King County Noxious Weed Control Program, and the King County Department of Natural Resources and Parks to learn more about aquatic noxious weeds and other natural resource management issues.

The public education program for Spring Lake will consist of two elements that will be implemented concurrently:

1. Noxious Aquatic Weeds Prevention and Detection

Initial eradication and control efforts are only worth doing if future infestations are prevented, or detected and eliminated soon after detection. Since the re-introduction of milfoil and other weeds to Spring Lake is almost certain, a prevention and detection plan is essential. There are three main elements to the prevention and detection plan:

a) Annual distribution of educational materials. Steering Committee members will compile published materials and generate literature specifically related to Spring Lake to distribute to all watershed residents each year at the beginning of the growing season.

b) Annual aquatic plant identification workshops. Workshops each spring will cover native plants as well as noxious aquatic weeds. Samples of our target weeds will be collected and pressed in Year 1 as a permanent reference and education tool for the community. All watershed residents and lake-users will be invited and encouraged to attend. The lakefront residents at Lake Desire, Shady Lake and other nearby waterbodies might also be invited to expand the educational effort beyond Spring Lake. Aquatic plant experts could be invited from Ecology, the King County Noxious Weed Control Program, or other applicable agencies. A better-educated community of residents and lake-users will be more likely to identify and report noxious aquatic weeds and other potential problems.

c) Two aquatic weed surveys each growing season. Volunteers (community members) will undergo training with lakes/aquatic plant specialists prior to conducting surveys. There are at least 10 certified divers living on the lake, several of whom have been active in developing the IAVMP and project proposal. Divers will be trained to survey the lake bottom to complement visual surveys from the surface and to take samples for identification.

2. Lake Stewardship Education Program

All residents in the watershed affect Spring Lake, although sometimes the cause and effect relationships are not readily apparent. Hopefully educating community members and other lake users will illuminate the relationship between human behaviors and water quality. Each watershed resident will be provided information on how to reduce the amount of pollutants entering the lake from their property. Property owners with lakeside lots will be provided information on lake-friendly landscaping, subsequently ensuring a healthier lake environment.

Improved signs will be posted at the boat ramp to inform lake-users of the problems caused by noxious aquatic weeds and how to prevent spreading them from lake to lake. The Steering Committee has generated some ideas for signage related to the transport of milfoil by boats and trailers. If the signs posted at the boat launch included step by step directions on how to properly clean boats and trailers, and why it is important, lake-users may be more apt to do the right thing. Obvious problems for boat cleaning involve questions of where it can be done and the right equipment to do the job. The boat launch at Spring Lake does not have any tools to perform this cleaning, which is similar to most other lakes in the area. Any adhering pollutants that are washed off by a diligent boat owner at the launch site will probably end up in the lake since there is no facility to collect the gray water. The Steering Committee has discussed the option of installing a Cleaning Station at the Spring Lake boat launch with a hose, handpump, and a catchment and drain to encourage the proper cleaning of boats and trailers. The handpump would hopefully discourage using the station for cleaning cars or other inappropriate uses. Spring Lake may pursue these issues with the Washington Department of Fish and Wildlife, which has just begun a pilot program to address these concerns.

WATERSHED AND WATERBODY CHARACTERISTICS

Watershed Characteristics

Spring (Otter) Lake's watershed is located in south-central King County, Washington in an unincorporated area located 6 miles east of Renton and 3.5 miles northwest of Maple Valley. State resource agencies frequently use a system of Water Resource Inventory Areas (WRIA) to refer to the state's major watershed basins. Spring Lake is located in WRIA 8, which refers to the Cedar-Sammamish combination watershed and includes Lake Washington, Lake Sammamish, and most of the City of Seattle.

The Spring Lake watershed constitutes approximately 450 acres (11%) of the Peterson Creek Sub-basin of the Lower Cedar River watershed. The Peterson Creek Sub-basin is 4043 acres and receives a mean annual rainfall of 44.4 in., with a water yield of 47.5% (or 21.1 in.). The Spring Lake watershed receives drainage from the steeply sloping areas surrounding the lake on the west, north and east sides. There are two small peaks to the northwest, one of which is referred to as Echo Mountain that rises more than 860 feet above sea level. There is a ridge on the eastside of Spring Lake that quickly rises 150 feet to peak at 620 feet along 196th Ave. SE. The remaining land, to the southwest of the lake, is a large wetland at the elevation of the lake (490 feet). The Spring Lake watershed is located on a plateau above the Cedar River in an area of an unusually high density of lakes. Within 2 mi^2 are Lake Desire (57 acres), Shady Lake (19 acres) and Peterson Lake (4 acres), all within the Peterson Creek Sub-basin. Shadow Lake (56 acres) and Lake Youngs (685 acres) are close by to the south. Lake Youngs is not open to the public because it is part of the City of Seattle Municipal Water Supply.

According to the Soil Survey for King County Area, Washington, the soils in the Spring Lake watershed are composed of five major soil series (U.S. Department of Agriculture, 1973). The primary soil series are Alderwood gravelly sandy loam in both 6-15% slopes (AgC) and 15-30% slopes (AgD). There is one small section of Norma sandy loam (No) on the northeast edge of the watershed along 196th Ave. SE. The large wetland area southwest of Spring Lake (LCR 28) is composed of Orcas peat (Or) in the north associated with the fen, and Seattle muck (Sk) to the south and on both sides of the outlet (Tributary 0328). The Alderwood soil association are moderately well drained, undulating to hilly soils that have dense, very slowly permeable glacial till at a depth of 20 to 40 inches. It is found in uplands and terraces. Its hydrologic properties differ dramatically from the underlying parent material. Compaction or removal of these soils during the typical urban or suburban development result in commensurately large hydrologic effects (King County, 1993). There is a significant area of recessional outwash mapped around Spring Lake (except on the east side), with all the surrounding area composed primarily of till. The recessional outwash area is largest in the southwest (LCR 28) and down along Tributary 0328 on both sides of Peterson Lake. This outwash corresponds directly with mapped areas of high groundwater recharge in the midst of the large area of low recharge that occurs on the till. Recharge occurs when the water level in a wetland is higher than the water table of its surroundings, and groundwater flows out of the wetland (Mitsch & Gosselink, 1993).

The Peterson Creek Sub-basin tributaries drain approximately 6.3 mi^2, including Spring Lake and Lake Desire. Over half the area is classified as forested, with another quarter of the land use as low-density residential, and 9% of the sub-basin classified as wetland. While this sub-basin is among the largest in the Cedar River Basin, it is also one of the least developed. Data from 1981 detailed land use within the Spring Lake watershed as follows: 8% residential-suburban, 77% forest or "unproductive", and 15% lake surface when there were 44 nearshore homes (70% of the shoreline in residential development) (Sumioka & Dion, 1985). There are now 76 nearshore homes, which indicates that single family high-density land use has continued to increase on the west side of the lake. Future land use plans include a single family, medium density area stretching along the eastside of the lake, west of 196th Ave. SE (King County, 1993). A 373-acre King County Park (Lake Desire/Spring Lake Park) occupies the remaining 30% of the shoreline in the southwest and around the outlet stream. The park supports only passive recreational uses on a small trail system through forest and adjacent to large wetland areas, and includes regionally valuable habitats like the rare plant communities found on the rocky bald of Echo Mt. and the large fen with its *Sphagnum* plant communities. The park is part of almost 1000 acres of contiguous parcels owned by King County, much of which is preserved as open space. In light of the habitat fragmentation that has degraded forest and wetland resources in the region, these tracts provide regionally significant wildlife corridors and habitat (King County, 1993).

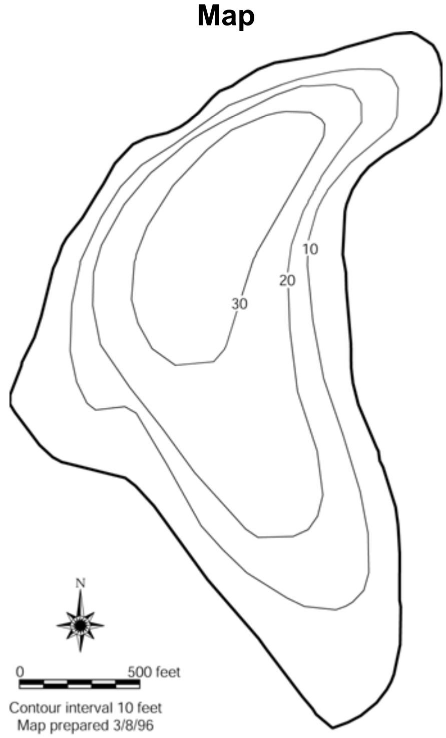
Tributary 0328 drains Spring Lake from its southern tip, and joins Tributary 0328B which drains Lake Desire immediately to the west. Spring Lake and Lake Desire's outlets join above Peterson Lake about 0.3 stream miles downstream from the outlet of Spring Lake. They flow southeast together as Tributary 0328 another 0.7 stream miles to Peterson Lake, and enter the Cedar River as Peterson Creek 1.6 stream miles downstream from an ecology-block weir that controls Peterson Lake's level. Both of these larger tributary channels are largely contained in a large Class 1 wetland system (LCR 28) that dominates much of the valley area downstream of Spring Lake. The surrounding wetlands and a lack of development protects the stream habitat in this reach. The banks of the stream are densely vegetated, mostly with deciduous woody plants, with low gradient channels that are dominated by silt. There is abundant coarse woody debris (CWD) that contributes to habitat complexity.

There is a significant amount of shoreline that remains relatively undeveloped at Spring Lake, including the large wetland system in the southwest (King County, 1993). This undoubtedly limits the nonpoint source nutrients reaching the lake. This entire sub-basin benefits from the moderating effects of its many wetlands and lakes, which act as detention ponds to reduce runoff "pulses." However, as the number of nearshore houses has increased around Spring Lake, so has the clearing of buffering native vegetation along the shoreline to provide landscaping or to enhance lake access and views. Nonetheless, many of the residential properties have maintained a buffer strip, which helps to filter out nutrients and pollutants before they enter the lake, as well as providing habitat. The public boat launch area is the only point where a road actually reaches the water. Spring Lake Drive, which provides access to all of the homes on the lake, is set several hundred feet away from the water on the other side of the homes. The runoff from the road filters through the lakeside properties. An important source of nonpoint-source pollution includes septic system failures, and Spring Lake has a reported failure rate of 11.5% from its 78 systems (King County, 1993). The average age for a repaired system is 20 years and non-repaired is 14 years, both of which are above the regional average. Two livestock-keeping locations were mapped in the Spring Lake watershed as of 1992. These locations are widely spaced within the watershed, include very small numbers of livestock, and are situated far from the lake. These two locations are unlikely to contribute significantly to the nonpoint nutrient source load for Spring Lake.

Waterbody Characteristics

Spring Lake is a 68-acre lake located in the southern half of its watershed in south central King County. The lake has a mean depth of 19 feet and a maximum depth of 32 feet, with an estimated lake volume of 1,300 acre-ft. Spring Lake has 7695 ft. (1.45 mi.) of shoreline with a shoreline configuration value of 1.3. There are no surface inflows to Spring Lake, with outflow into Tributary 0328 occurring year round into the natural outlet channel with no manmade flood control structures. There is public boat access to the lake provided by a boat launch owned by the Washington Department of Fish & Wildlife (WDFW) located on the north edge of the King County Park. Spring Lake flushes an estimated 136 % of its volume annually. This number was calculated by multiplying the average annual rainfall (3.67 ft) by the watershed area (480 acres), then dividing by the estimated lake volume (1300 acre-feet). This value is an overestimate, as it does not account for water lost to evapotranspiration within the watershed.

Figure 1: Spring Lake Bathymetric Map



Lower Cedar River wetland 28 (LCR 28), adjacent to Spring Lake, is an 83-acre Class 1 system located within the 373 acre King County Park. Inventoried wetlands are rated from 1-3 according to specific criteria in the King County Sensitive Areas Ordinance. The wetland rating system is based on size, vegetative complexity, and the presence of threatened or endangered species. LCR 28 includes a large (69-acre), extraordinarily high quality *Sphagnum*/Labrador tea fen and hemlock swamp at the southeast shore of the lake. The primary productivity of peat wetlands is low although peat accumulations may be significant (Mitsch & Gosselink, 1993). Plants in these systems have evolved unique mechanisms to cope with a number of harsh growing conditions, including elevated bog/fen mat temperatures in summer, acidic conditions, low nutrients and low oxygen supply to their roots. LCR 28 contains the plant species common to western Washington peatlands: *Sphagnum* and *Hypnum* mosses, Labrador tea (*Rhododendron groenlandicum*), bog laurel (*Kalmia microphylla*), bog cranberry (*Vaccinium oxycoccus*), sundew (*Drosera rotundifolia*), and hemlock (*Tsuga heteropylla*). The fen also contains unusually high densities of mature lodgepole pine (*Pinus contorta* var. *latifolia*) for this side of the Cascades (King County, 1993). Depth of the peat deposits indicate the wetland is more than 10,000 years old (Rigg, 1958). The National Wetlands Inventory found five wetland and deepwater habitat classifications associated with LCR 28 (Cowardin et. al., 1979). Four wetland habitats were classified: palustrine emergent, seasonally flooded (PEMC), palustrine forested, needle-leaved evergreen, temporarily flooded (PFO4A), palustrine scrub-shrub, temporarily flooded (PSSA), and palustrine forested, seasonally flooded (PFOC). Palustrine systems generally include all non-tidal wetlands dominated by trees, shrubs, emergents, mosses, or lichens. Seasonally flooded systems have surface water present for extended periods during the early growing season, but this water is usually absent by the end of the growing season in most years. Whereas temporarily flooded systems have surface water present for only brief periods during the growing season, but the water table usually lies well below the surface. There is also a deepwater habitat classified as lacustrine limnetic, unconsolidated bottom, permanently flooded (L1UBH). This lacustrine system is associated with Spring Lake proper.

Since almost half of the shoreline is undeveloped (as of 1993), LCR 28 is in better condition than any other wetlands within the Basin Planning Area. “Indeed it is arguably the most pristine wetland in the Surface Water Management service area” (King County, 1993). Small foot trails and a campsite were degrading the quality of the hemlock swamp, and use has now been officially discouraged by camouflaging the trailhead and posting signs asking that visitors stay out of the wetland. A small portion of the *Sphagnum* mat near the lake outlet at stream mile 2.7 is disintegrating and becoming colonized by acid-neutral species such as soft rush and sedges (King County, 1993). Both LCR 28 and Spring Lake are considered regionally significant resource areas. This is a designation used in King County Basin Plans to indicate areas that contribute to the resource base of the entire southern Puget Sound region by virtue of exceptional species and habitat diversity and abundance, when compared to aquatic and terrestrial systems of similar size and structure elsewhere in the region (King County, 1993). The sediments in Spring Lake are mainly loose and unconsolidated, with high silt and organic components. Some areas are very flocculent, especially in the undeveloped south end of the lake. The majority of the residential parcels also have loose sediment away from the shoreline. A few residents have added gravel to shallow areas.

While part of LCR 28’s immediate subcatchment is protected as open space, the wetland was platted before the Sensitive Areas Ordinance (SAO) came into effect. This means that large areas of the wetland might be cleared and filled for homesites, roads, and utility lines under the reasonable use provisions of the SAO. Since fen plant communities are especially fragile, this wetland is especially vulnerable to impacts from future development. Portions of the lake shoreline are slated for build-out at densities that will increase from single- to medium-density, single-family residential development.

Continued *Sphagnum* disintegration could lead to an undesirable release of nutrients into the lake and possibly to irreversible invasion of the fen by hardhack spiraea and cattails.

Water Quality

Since 1985, King County residents have participated in a volunteer monitoring program to create a long-term record of water quality for the region's small lakes. The volunteers from Spring Lake have contributed samples starting with the very first year (1985) of the program (King County, 2001). The data record for Spring Lake is largely complete with data missing for only one year, 1995. Prior to this time, the former Municipality of Metropolitan Seattle (METRO) performed annual lake monitoring in the time periods 1971-1972 and 1974-1977.

The assessment of biological activity or trophic state results in the classification of lake water quality into three general categories: oligotrophic, mesotrophic, and eutrophic. Lakes with low concentrations of algae are considered oligotrophic, lakes with high concentrations of algae are considered eutrophic. Lakes whose quality ranges between eutrophic and oligotrophic are considered mesotrophic. One of the most common measures used to calculate a lake's water quality classification is the numerical trophic state index (TSI) developed by Robert Carlson (1977). This index allows comparison of lake water quality by rescaling water clarity, phosphorous, and chlorophyll *a* along a trophic continuum based on a scale of 0 to 100 related to algal biovolumes. Lakes may be naturally eutrophic, mesotrophic, or oligotrophic based on the inherent character and stability of the surrounding watershed. Eutrophication or the increase in a lake's biological activity over time is a process that occurs naturally in some lakes and may be accelerated in others by human activities.

For Spring Lake, productivity is mesotrophic (moderate), characterized by moderate water clarity and chlorophyll *a* values, and low to moderate phosphorous levels. Data from the 16-year record from 1985 to 2000 are summarized in Table 1, taken from King County Lake Water Quality: A Trend Report on King County Small Lakes (November 2001)

Table 1. Average Values for Select Trophic Parameters at Spring Lake

Year	No. of Samples	Secchi (meter)	Chl *a** (µg/L)	TP* (µg/L)	TSI* Secchi	TSI* Chl *a*	TSI* TP	TSI* Average
1985	11	2.7	3.5	14	46	43	42	44
1986	8	2.5	3.1	13	47	42	41	43
1987	11	2.8	3.0	13	45	41	42	43
1988	10	2.9	3.2	14	44	42	42	43
1989	10	3.0	3.0	13	44	41	41	42
1990	11	2.5	2.5	11	47	39	39	42
1991	11	2.3	3.8	16	48	44	44	45
1992	10	2.6	2.9	14	46	41	42	43
1993	10	2.5	4.7	19	47	46	46	46
1994	11	3.3	6.6	21	43	49	48	47
1995	---	---	---	---	---	---	---	---
1996	12	2.5	3.5	15	47	43	43	44
1997	12	2.1	4.4	16	49	45	44	46
1998	13	2.9	3.9	13	45	44	41	43
1999	13	2.7	4.6	10	46	46	37	43
2000	13	2.6	4.2	10	46	45	38	43

*Chl *a* = chlorophyll *a*, TP = total phosphorus, and TSI = Trophic State Index

Summary of water quality characteristics

- water clarity (Secchi depth) ranged from 2.1 – 3.3 meters (May-October average)
- total phosphorous ranged from 10 – 21 µg/L (May-October average)
- Chlorophyll *a* ranged from 2.9 – 6.6 µg/L (May-October average), but most years were below 4.0
- TSI Secchi ranged from 43 – 49
- TSI Chl *a* ranged from 39 – 49

- TSI TP ranged from 37 – 48
- TSI annual average 43 – 47

Trend analysis (using the non-parametric Mann-Kendall's test for trend at the 95% confidence interval) was performed on the water quality data sets to evaluate whether statistically significant changes have occurred at Spring Lake (King County, 2001). A significant upward trend was noted for chlorophyll *a* (n=15; p=0.05, slope=0.098) suggesting a slight increase in algal levels has occurred at Spring Lake between 1985 and 2000. Overall, water quality at Spring Lake is good and is certainly influenced by a large wetland (LCR 28) to the southwest of the lake. Groundwater also plays an important role in maintaining good lake water quality. Long-term, local stewardship by lake residents remains important to ensure ongoing erosion and nutrient control measures take place as land is developed in the watershed or local shoreline alteration occurs.

Fish and Wildlife Communities

Spring Lake and its surrounding habitats support a variety of fish, birds, and animals by providing nesting, forage, and cover. According to Washington Department of Fish and Wildlife (WDFW) the resident fish species in Spring Lake include rainbow trout (*Oncorhynchus gairdneri)*, yellow perch (*Perca flavescens)*, largemouth bass (*Micropterus salmoides)*, pumpkinseed (*Lepomis gibbosus)*, and brown bullhead (*Ictalurus nebulosus)* (Congleton et. al., 1977). Black crappie (*Pomoxis nigromaculatus)* has also been caught recently by a resident (K. Heikell, pers. comm.)

Spring Lake is managed as a mixed species fishery (C. Jackson, pers. comm.). Mixed species means that the WDFW manages for both warmwater (bass and sunfish) and coldwater (trout) angling opportunities. Warmwater species are self-maintaining, whereas coldwater species are augmented through annual stocking. Spring Lake has been planted with catchable trout (8-10" in length) since 1956. On average, Spring Lake receives about 4,500 rainbow trout, but plants have been as low as 3,000 and as high as 7,000. Stocking differences are attributed to annual variability in hatchery production.

Spring Lake is open all year to recreational angling and according to residents and WDFW, usually hosts several anglers per day between late March through October. However, most of the visits occur in early spring when the lake is stocked. Spring Lake falls under the General Statewide Regulations for limits and size restrictions set by WDFW.

A Limiting Factors Analysis for WRIA 8 found Coho salmon (*Oncorhynchus kisutch*) in Tributary 0328 as far up as the confluence with Tributary 0328B (stream mile 2.4), the outlet stream for Lake Desire (D. O'Connor, pers. comm.). Coho were present in Tributary 0328 up to the plateau that is below Spring Lake (King County, 1993). The section of Peterson Creek below Peterson Lake (stream mile 1.6-0.0) is used by all species of anadromous salmonids indigenous to the Cedar River Basin, which includes Coho, Sockeye (*Oncorhynchus nerka)*, and fall Chinook (*Oncorhynchus tshawytscha)*.

The residents of Spring Lake generated a list (Table 2) that includes 69 species of birds seen around the lake in casual observation. This list includes eight species of regulatory significance including the great blue heron, wood duck, bald eagle, osprey, common goldeneye, hooded merganser, pileated woodpecker, and bufflehead. The proximity to lakes and an open water component at wetlands increases bird richness (Richter & Azous, 2001b). This study identified a total of 90 bird species on at least two or more occasions over a three-year period at their study sites. No single wetland exhibited more than 69% (62) of species found across all wetlands. The diverse habitats at Spring Lake are obviously of essential importance to the bird communities in this area.

The high quality mixed forest and wetland plant communities provide excellent non-breeding habitat for a diverse assemblage of Puget Sound lowland amphibian species. The Pacific chorus frog (*Pseudacris regilla*) and Northern red-legged frog (*Rana aurora*) have often been seen or heard around Spring Lake, especially during the breeding season in early spring. These systems also provide excellent habitat for our common Ambystomid salamanders such as the Northwestern salamander (*Ambystoma gracile*) and long-toed salamander (*Ambystoma macrodactylum*). Unfortunately, the non-native bullfrog (*Rana catesbeiana*) is quite common at Spring Lake, and they can have a negative impact on our native amphibians through direct predation (Richter & Azous, 2001a). Beaver (*Castor canadensis*) are frequently seen and heard around the lake, whereas river otter (*Lutra canadensis*) are considered a rare treat to observe (T. Barnes, pers. comm.). Several other mammals supported by the adjacent forest include the mountain beaver (*Aplodontia rufa)*, Douglas' squirrel (*Tamiasciurus douglasii)*, and chipmunk (*Eutamias townsendii)*.

Table 2. Common Spring Lake Birds (* = confirmed nesting)

Accipitridae	**Emberizidae**	**Podicipedidae**
Bald Eagle	Spotted Towhee*	Pied-billed Grebe
Red Tail Hawk	Song Sparrow*	
Cooper's Hawk	Fox Sparrow	**Rallidae**
Sharp Shinned Hawk	Dark-Eyed Junco (OR & Slate-Colored)*	American Coot
Osprey		
	Icteridae	**Regulidae**
Aegithalidae	Red-Winged Blackbird*	Golden-Crowned Kinglet*
Bushtit	Brown Headed Cowbird	Ruby-Crowned Kinglet
Alcedinidae	**Falconidae**	**Sittidae**
Belted Kingfisher	Merlin	Red-Breasted Nuthatch*
Anatidae	**Fringillidae**	**Strigidae**
Canada Goose*	Evening Grosbeak	Barred Owl*
Wood Duck*	Purple Finch	
Mallard*	House Finch	**Sturnidae**
Common Goldeneye	Pine Siskin	European Starling
Bufflehead	American Goldfinch	
American Widgeon		**Thraupidae**
Northern Pintail	**Gaviidae**	Western Tanager
Common Merganser	Common Loon	
Hooded Merganser		**Trochilidae**
Northern Shoveler	**Hirundinidae**	Anna's Hummingbird*
Ring-necked Duck	Violet-Green Swallow*	Rufous Hummingbird
Ruddy Duck	Tree Swallow	
Lesser Scaup	Barn Swallow	**Troglodytidae**
		House Wren*
Ardeidae	**Laridae**	Winter Wren*
Great Blue Heron	Gull, species unknown	Marsh Wren*
		Bewick's Wren
Bombycillidae	**Paridae**	
Cedar Waxwing	Black-Capped Chickadee*	**Turdidae**
	Mountain Chickadee	Varied Thrush
Cardinalidae	Chestnut-Backed Chickadee*	American Robin*
Black-headed Grosbeak*		
	Picidae	
Certhiidae	Red Breasted Sapsucker	
Brown Creeper*	Downy Woodpecker	
	Hairy Woodpecker	
Columbidae	Northern Flicker*	
Band-Tailed Pigeon	Pileated Woodpecker*	
Corvidae	**Phalacrocoracidae**	
Stellars Jay*	Double–Crested Cormorant	
American or Northwestern Crow*		

Beneficial and Recreational Uses

Spring Lake and its surroundings support a variety of uses to humans. Recreational activities include swimming, fishing, boating (no combustion motors), bird watching, wildlife viewing, and hiking (see Figure 2). Residents access the lake for these activities from any of the small private docks around the lake associated with the residential parcels. A public boat launch maintained by Washington Department of Fish & Wildlife allows everybody to benefit from this beautiful resource as well. There are no official swimming beaches associated with the King County Park. However, the park has miles of trails that meander through a mixed forest system adjacent to the wetland complex that allow for botanizing and wildlife viewing opportunities. The Washington Trails Association continues to provide volunteer labor in keeping these trails open and enjoyable.

No internal combustion engines are allowed on the lake (KCC 12.44.330), consequently there are no activities such as water skiing or jet skiing. One consequence of this ban is that the natural character and integrity of the system have been preserved. Also, the system is spared potential pollution from petroleum releases and noise pollution. There is also no hunting allowed on Spring Lake or in the adjacent King County Park.

Characterization of Aquatic Plants in Spring Lake

The plant communities in and around Spring Lake represent a diverse set of ecotypes. Hundreds of species occur in specific habitats represented in the area. Even the rocky bald atop Echo Mt. in the King County Park contains uncommon wetland plants due to the shallow subsurface hydrology. The aquatic vegetation serves a wide array of functions such as supporting food chains, providing habitat for a variety of animal species, intercepting sediment and removing toxic compounds from runoff, and providing erosion control/bank stabilization for lakes and streams.

The most recent comprehensive aquatic plant survey of Spring Lake occurred on July 22, 1994 as part of a plant-mapping project on 36 lakes carried out by King County's Lake Stewardship Program (King County, 1996). The surveys were conducted by boat using a two-person crew plus a volunteer (or volunteers) when available. Surveyors used GPS to establish shoreline sections between two fixed points. Each shoreline section was characterized by community type, species present, percent cover of community type, and relative species density within a community type. Community types were defined as emergent, floating, or submergent (Figure 3).

Figure 2. Beneficial Uses

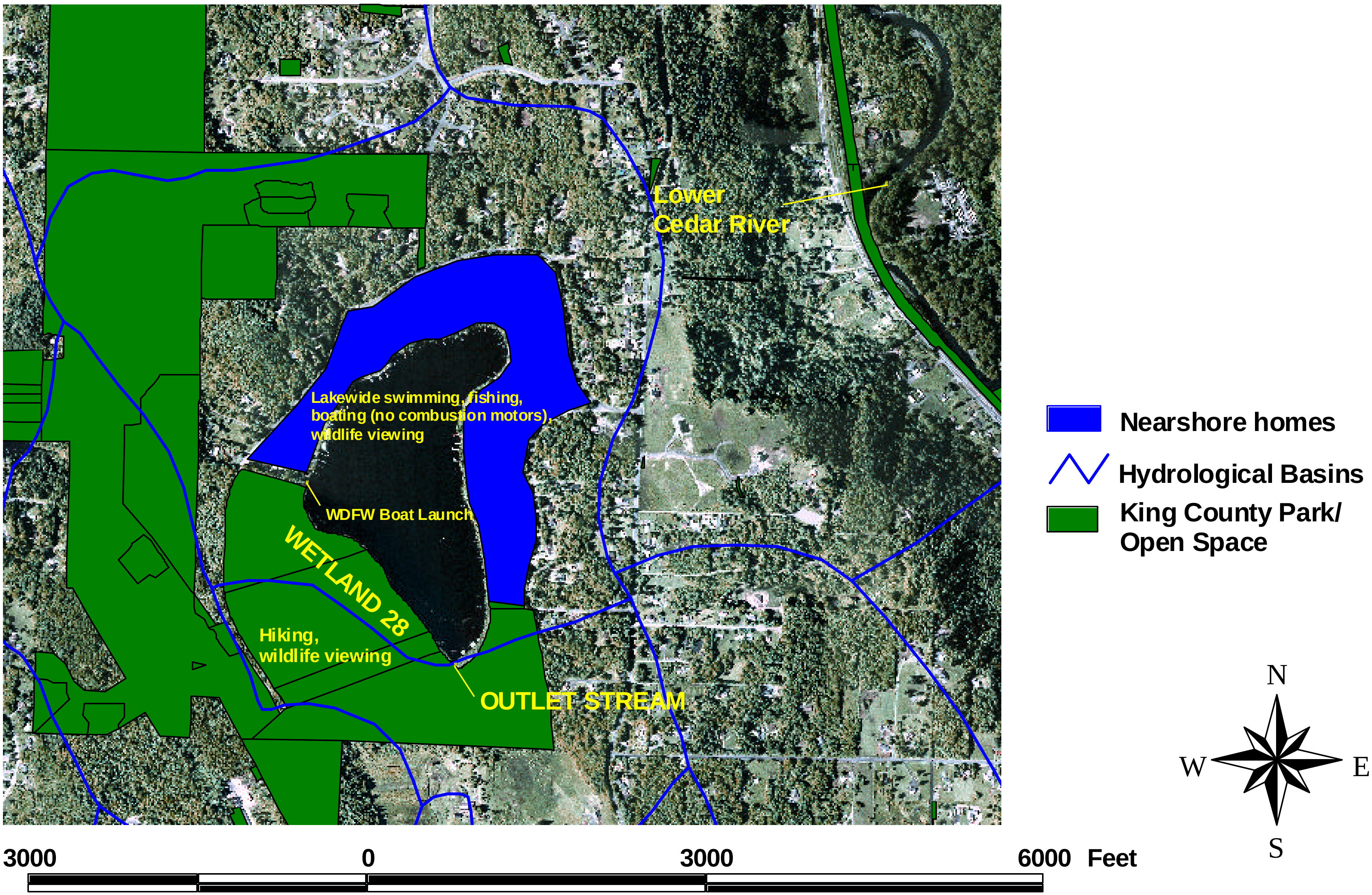
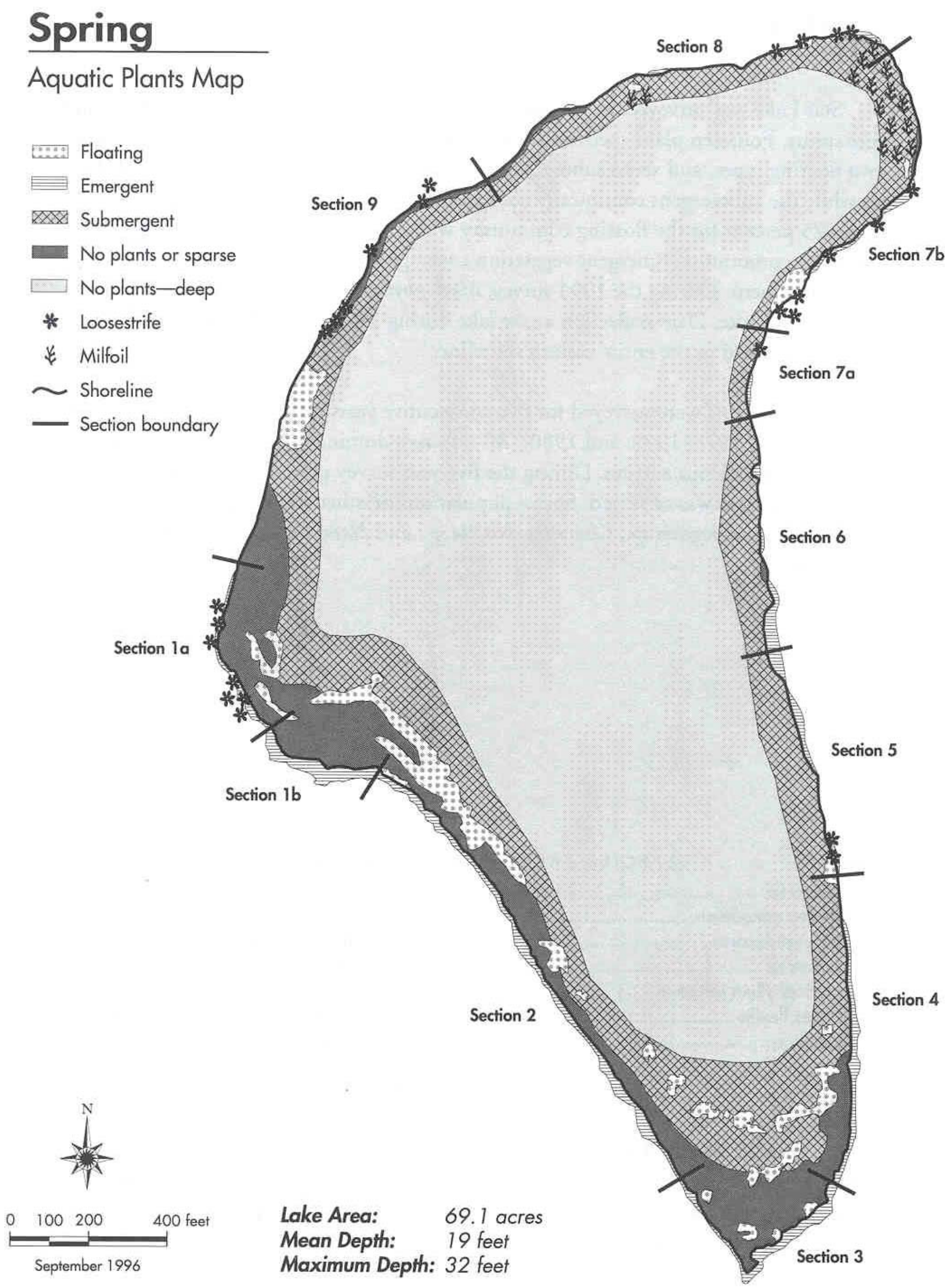


Figure 3. Spring Lake Aquatic Plant Survey Results, reprinted from King County, 1996



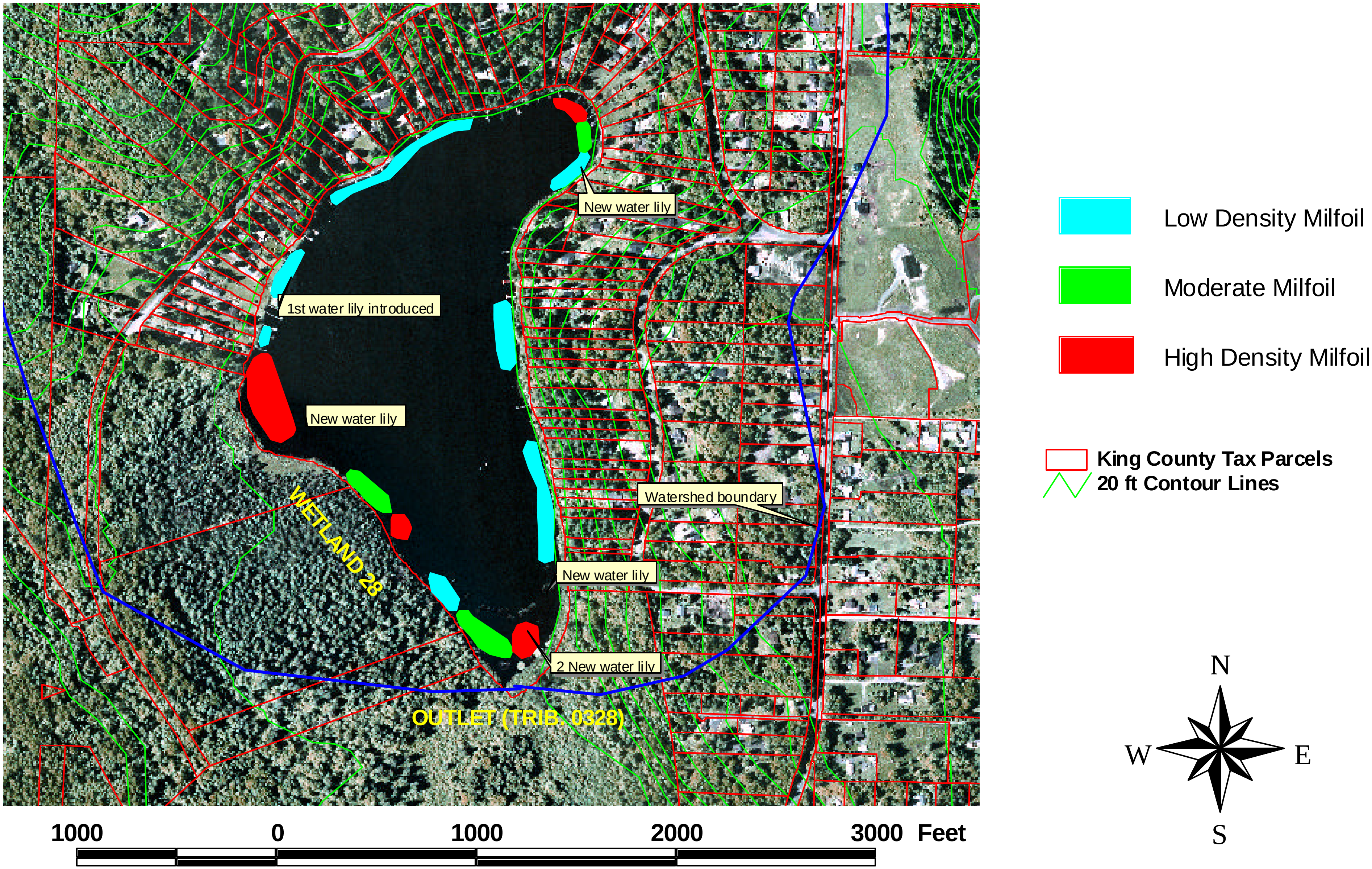
Twenty-six plant species (see Table 3) were identified at Spring Lake, including thirteen emergent types, four floating types, and nine submergent types. Emergents are plants that are rooted in the sediment at the water's edge but have stems and leaves which grow above the water surface. Floating rooted plants are rooted in the sediment and send leaves to the water's surface. Submergent plants are either freely-floating or are rooted in the lake bottom but grow within the water column. The floating plant coverage totaled 2.1 acres, the emergent plants totaled 1.8 acres, while the submergent community comprised 13.8 acres. Percent cover was variable throughout the lake for both the floating and submergent communities, with a total plant coverage of 23% for all three types. Plant coverage was greatest along the southwestern portion of the lake where LCR 28 (see Waterbody Characteristics) has been preserved along the shoreline. *Myriophyllum spicatum* was found only in the northern end of the lake in 1994, and several patches of *Lythrum salicaria* were also found along the shoreline.

On July 19, 2002, King County Aquatic Noxious Weed Specialist Drew Kerr and two members of the Steering Committee conducted a survey for aquatic noxious weeds. The survey was conducted by boat using a Global Positioning System (GPS) receiver. Approximated densities of *M. spicatum* were recorded as low, moderate, and high for the littoral zone of the lake. These individual points were connected into clusters of like-density in the post-processing using the Geographic Information System (GIS) program ArcView (Figure 4). New patches of *Nymphaea odorata* were also recorded based on the experience of the two community members. Parcels with *Lythrum salicaria* were also recorded. Both *M. spicatum* and *L. salicaria* appear to have greatly expanded their occurrence on the lake relative to the 1994 survey. *M. spicatum* is now found in higher concentrations around much of the littoral zone of the lake. There are new, low-density areas along the eastern and western shorelines, with higher densities from the boat launch south to the outlet, unlike the 1994 survey findings.

Table 3. Aquatic Plants Found in Spring Lake. Reformatted from King County, 1996.

Plant Species	Ab.	Common Name	Community	Sections Found
Brasenia schreberi	Bs	Water Shield	Floating	1a, 2, 3
Carex sp.	Ca	Sedge	Emergent	2
Chara sp.	Cs	Muskgrass	Submersed	unidentified
Dulichium arundinaceum	Da	Three-way Sedge	Emergent	2
Elodea canadensis	Ec	Water Weed	Submersed	1a, 2, 3, 4, 6, 7b, 8, 9
Iris pseudacorus	Ip	Yellow Flag Iris	Emergent	1a, 3, 6, 7a, 7b, 9
Isoetes sp.	Is	Quillwort	Submersed	6, 9
Juncus sp.	Ju	Rush	Emergent	1b, 2, 8
Ledum groenlandicum	Lg	Labrador Tea	Emergent	2
Ludwigia palustris	Lp	Water Purslane	Emergent	5, 6
Lythrum salicaria	Ls	Purple Loosestrife	Emergent	1a, 5, 7a, 7b, 9
Myriophyllum spicatum	Ms	Eurasian Watermilfoil	Submersed	7b, 8, 9
Najas flexilis	Nf	Slender Water-Nymph	Submersed	1a, 2, 3, 4, 7b, 9
Nitella sp.	Ni	Nitella	Submersed	4, 6, 7b, 8
Nuphar luteum	Nl	Yellow Water Lily	Floating	1a, 2, 3, 4, 5, 8
Nymphaea odorata	No	Fragrant Water Lily	Floating	3, 8, 9
Polygonum sp.	Pm	Smartweed	Emergent	5, 6
Potamogeton pusillus	Pb	Small Pondweed	Submersed	3, 4, 6, 7b, 8
Potamogeton epihydrus	Pe	Ribbonleaf Pondweed	Submersed	1a, 4, 7b
Potentilla palustris	Pp	Marsh Cinquefoil	Emergent	5, 6
Sagittaria sp.	Sa	Arrowhead	Emergent	1a
Spiraea douglasii	Sd	Spiraea	Emergent	1a, 1b, 2, 3, 4, 5, 6, 7b, 8
Spirodela polyrrhiza	Sp	Giant Duckweed	Floating	2
Typha angustifolia	Ta	Narrowleaf Cattail	Emergent	4
Typha latifolia	Tl	Cattail	Emergent	All
Utricularia sp.	Us	Bladderwort	Submersed	1a, 2

Figure 4. Eurasian watermilfoil & new fragrant water lily distribution in Spring Lake (8/21/02)



The northern tip of Spring Lake continues to support milfoil throughout the littoral zone, including an area of dense concentration. *Lythrum salicaria* is now common in buffer shoreline vegetation, and there are additional stands along the shore of LCR 28 and east of the outlet channel. No significant infestations have been found in the core of the wetland. Populations and distribution of *L. salicaria* have been partially contained by community efforts to stop seed production through manual control efforts, but the plant has obviously continued to increased from 1994 through 2002 to be at the current levels despite these recent control efforts.

Historical plant surveys of Spring Lake were carried out in four of five consecutive years from 1976 to 1980 (King County, 1996). In 1976, the dominant plants in the lake included *Brasenia schreberi, Nitella sp.,* and *Nymphaea odorata.* By 1980, after several intervening herbicide applications, *Elodea canadensis, Najas flexilis,* and *Potamogeton pusillus* were the dominant submergent plants present in the lake. These three species, along with *M. spicatum*, still comprise the majority of the submergent plant community. *M. spicatum* has been in the lake since before 1976 and herbicide has been used to control this noxious weed in the past. Records from the Spring Lake Community Club show that Aquathol granular was applied at 1.5 ppm in June 1978 to control aquatic plants in front of several lots (A & T Weed Service, 1978). In June of 1989, Sonar was applied to Spring Lake to control the submersed aquatic weeds and enhance the recreational value of the lake (Allied Aquatics, 1989). Records indicate that Allied Aquatics also performed an herbicide application for submersed aquatics in 1987.

Two species of aquatic plants occurred only in Spring Lake out of the 36 lakes surveyed in the 1996 report. *Spirodela polyrrhiza* is a native species of duckweed uncommon to the region, though found worldwide. *Typha angustifolia* (lesser cattail) is a non-native cattail currently establishing along the Pacific Coast that is native to Europe and possibly to the Atlantic Coast. It has narrower leaves and flowers than our native cattail (*Typha latifolia*) and is shorter in total height. The male flowers of lesser cattail are separated from the female flowers by a section of naked stem, whereas they are contiguous in the native species. It can grow in deeper water than *Typha latifolia*, and can form dense exclusive stands, which reduce plant biodiversity and the habitat functions supported by a mosaic of species. Allelopathic chemicals that inhibit the growth of other plants are produced by several cattail species. This may give it a competitive advantage over other wetland plants. Also, robust hybrids between the two plants will form, (called *T.* x *glauca*), which could potentially pollute the genetics of our native cattail. *Typha angustifolia*, although not currently widespread, is thought to be a potential invasive species problem in the future, and has been added as a Monitor Species to the Washington State Noxious Weed List. The stand on the Spring Lake shoreline is still fairly small and discrete and will be targeted for removal along with the four listed noxious weed species.

The Washington Natural Heritage Program (WNHP) performed a search of their Natural Heritage Information System database for rare plant species, select rare animal species, and high quality wetland and terrestrial ecosystems in the vicinity of Spring Lake (http://www.wa.gov/dnr/htdocs/fr/nhp/wanhp.html). This search did not find any endangered, threatened, or sensitive plant species recorded for Spring Lake, nor did it find the presence of any animal species tracked by their system. Two high quality wetland ecosystems were found by the search, one a forested wetland ecosystem and the other a forested fen ecosystem. The fen, which is located adjacent to the southwest shoreline, contains western hemlock (*Tsuga heterophylla*), western redcedar (*Thuja plicata*), Labrador tea (*Rhododendron groenlandicum*), and *Sphagnum* spp. The forested wetland, which occurs between the fen and the mixed forest uplands, contains western hemlock and western redcedar, as well as skunk cabbage (*Lysichiton americanus).* Both of these systems are part of the large, Class 1 wetland LCR 28.

Noxious Aquatic Weeds in Spring Lake

Table 3 shows the 26 species found in the 1994 plant survey, including four listed noxious weed species: Eurasian watermilfoil (*Myriophyllum spicatum),* purple loosestrife (*Lythrum salicaria),* fragrant water lily (*Nymphaea odorata)*, and yellow flag iris (*Iris pseudacorus)*. These species will be the focus of the plant management efforts on Spring Lake. The term “noxious weed” refers to those non-native plants that are legally defined by Washington’s Noxious Weed Control Law (RCW 17.10) as highly destructive, competitive, or difficult to control once established. Noxious weeds have usually been introduced accidentally as a contaminant, or as ornamentals. Non-native plants often do not have natural predators (i.e. herbivores, pathogens) or strong competitors to control their numbers as they may have had in their home range. WAC 16.750 sets out three classes (A, B, C) of noxious weeds based on their distribution in the state, each class having different control requirements. County Weed Boards are given some discretion as to setting control priorities for Class B and C weeds. Eurasian watermilfoil and purple loosestrife are both Class B Noxious Weeds, while fragrant water lily and yellow flag iris are Class C Noxious Weeds.

Eurasian watermilfoil (*Myriophyllum spicatum*)

Eurasian watermilfoil is native to Europe, Asia, and North Africa and also occurs in Greenland (Washington State Noxious Weed Control Board, 1995). The oldest record of Eurasian watermilfoil in Washington is from a 1965 herbarium specimen collected from Lake Meridian, King County. It was first identified causing problems in the 1970s in Lake Washington and proceeded to move down the I-5 corridor, probably transported to new lakes on boats and trailers. Eurasian watermilfoil is among the worst aquatic pests in North America. *M. spicatum* is a submersed, perennial aquatic plant with feather-like leaves. It usually has 12 to 16 leaflets (usually more than 14) on each leaf arranged in whorls of 4 around the stem. Leaves near the surface may be reddish or brown. Sometimes there are emergent flower stalks during the summers that have tiny emergent leaves. In western Washington, Eurasian watermilfoil frequently over-winters in an evergreen form and may maintain considerable winter biomass (K. Hamel, pers. comm.). This plant forms dense mats of vegetation just below the water’s surface. In the late summer and fall, the plants break into fragments with attached roots that float with the currents, infesting new areas. Disturbed plants will also fragment at other times of the year. A new plant can start from a tiny piece of a milfoil plant. *M. spicatum* was not previously thought to reproduce from seed in this region. However, aquatic plant experts are beginning to think that milfoil seeds might be playing a bigger role in repopulating lakes than was previously hoped (K. Hamel, pers. comm.). This is especially true if the lake dewaters. Milfoil starts spring growth earlier than native aquatic plants, and thereby gets a "head start" on other plants. Eurasian watermilfoil can degrade the ecological integrity of a water body in just a few growing seasons.

Dense stands of milfoil crowd out native aquatic vegetation, which in turn alters predator-prey relationships among fish and other aquatic animals. Eurasian watermilfoil can also reduce dissolved oxygen – first by inhibiting water mixing in areas where it grows, and then as oxygen is consumed by bacteria during decomposition of dead plant material. Decomposition of *M. spicatum* also releases phosphorus and nitrogen to the water that could increase algal growth. Further, dense mats of Eurasian watermilfoil can increase water temperature by absorbing sunlight, raise the pH, and create stagnant water mosquito breeding areas. Eurasian watermilfoil will negatively affect recreational activities such as swimming, fishing, and boating. The dense beds of vegetation make swimming dangerous, snag fish hooks on every cast, and inhibit boating by entangling propellers or paddles and slowing the movement of boats across the water.

At Spring Lake, *M. spicatum* is generally moderate in density. The infestation is still patchy with only a few high-density milfoil stands. Most of the patches are still moderate to low density, and therefore are not yet causing enormous impacts. The infestation has grown significantly since the last measurement in 1994, both in size and distribution. It is likely that the milfoil infestation will continue to expand if left untreated, dramatically increasing negative impacts to the beneficial uses of Spring Lake.

Purple loosestrife (*Lythrum salicaria*)

Purple loosestrife is native to Europe and Asia and was introduced through ship ballast water to the Atlantic Coast in the mid-1800s (Washington State Noxious Weed Control Board, 1997). In Washington, purple loosestrife was first collected from the Seattle area in 1929 from Lake Washington. Purple loosestrife is a perennial that can reach 9 feet tall with long spikes of magenta flowers. The flowers usually have 6 petals, and the stems are squared-off. Purple loosestrife is considered a facultative wetland (+) species (FACW+), with a 67-99% probability of occurring in wetlands as opposed to upland areas (Reed, 1988). Vigorous plants can produce over 2 million tiny, lightweight seeds (120,000 per spike) that are easily spread by waterfowl and other animals (Washington State Noxious Weed Control Board, 1997). Although a prolific seeder, purple loosestrife can also spread through vegetative production by shoots and rhizomes as well as by root fragmentation. It has a woody taproot with a fibrous root system that forms a dense mat, keeping other plants from establishing in a space.

Purple loosestrife disrupts wetland ecosystems by displacing native or beneficial plants and animals. Waterfowl, fur-bearing animals, and birds vacate wetland habitat when native vegetation is displaced by purple loosestrife. Loss of native vegetation results in decreased sources of food, nesting material, and shelter. Economic impacts are high in agricultural communities when irrigation systems are clogged or when wet pastures are unavailable for grazing. Purple loosestrife is aggressive and competitive, taking full advantage of disturbance to natural wetland vegetation caused by anthropogenic alterations of the landscape. Seed banks build for years since seeds may remain viable for up to 3 years. Monospecific stands are long-lived in North America as compared to European stands, illustrating the competitive edge loosestrife has over other plant species.

Purple loosestrife has already colonized the shoreline of the fragile fen system in LCR 28 and will disperse further up into the wetland if not controlled. Purple loosestrife has not been found yet one mile downstream at the Peterson Lake Park Natural Area (King County, 1999). However, this species could easily be transported downstream from Spring Lake by seed to invade this valuable resource area.

Fragrant water lily (*Nymphaea odorata*)

This noxious weed is native to the eastern half of North America (Washington State Noxious Weed Control Board, 2001b). It was probably introduced into Washington during the Alaska Pacific Yukon Exposition in Seattle in the late 1800's. It has often been introduced to ponds and lakes because of its beautiful, large white or pink (occasionally light yellow), many-petaled flowers that float on the water's surface, surrounded by large, round green leaves. The leaves are attached to flexible underwater stalks rising from thick fleshy rhizomes. Adventitious roots attach the horizontal creeping and branching rhizomes.

This aquatic perennial herb spreads aggressively, rooting in murky or silty sediments in water up to 7 feet deep. It prefers quiet waters such as ponds, lake margins and slow streams and will grow in a wide range of pH. Shallow lakes are particularly vulnerable to being totally covered by fragrant water lilies. Water lily spreads by seeds and by rhizome fragments. A planted rhizome will cover about a 15-foot diameter circle in five years (Washington State Noxious Weed Control Board, 2001b). This can reduce the important open water component in the littoral zone of Spring Lake.

Fragrant water lily (*Nymphaea odorata)*, first introduced by a homeowner, is quickly expanding its distribution on Spring Lake (T. Barnes, pers. comm.). When uncontrolled, this species tends to form dense monospecific stands that can persist until senescence in the fall. Mats of these floating leaves prevent wind mixing and extensive areas of low oxygen can develop under the water lily beds in the summer. Water lilies can restrict lakefront access and hinder swimming, boating, and other recreational activity. They may also limit our native water lily (*Nuphar luteum)* with which it overlaps in distribution. The fragrant water lily is still expanding in patches on Spring Lake, and so its future impacts are not clear. As soon as these patches connect, recreational activities such as boating, fishing, and swimming will become more difficult. Even canoes can have great difficulty moving across dense floating mats of fragrant water lily, not to mention entanglement with propellers of boat motors.

Yellow flag iris (*Iris pseudacorus*)

Yellow flag iris is native to mainland Europe, the British Isles, and the Mediterranean region of North Africa (Washington State Noxious Weed Control Board, 2001a). This plant was introduced widely as a garden ornamental. It has also been used for erosion control. The earliest collection in Washington is from Lake McMurray in Skagit County in 1948 (Washington State Noxious Weed Control Board, 2001a). The yellow flowers are a distinguishing characteristic, but when not flowering it may be confused with cattail (*Typha sp.*) or broad-fruited bur-reed (*Sparganium eurycarpum*).

Yellow flag iris is considered an obligate wetland species (OBL), with a >99% probability of occurring in wetlands as opposed to upland areas (Reed, 1988). The plants produce large fruit capsules and corky seeds in the late summer. Yellow flag iris spreads by rhizomes and seeds. Up to several hundred flowering plants may be connected rhizomatously. Rhizome fragments can form new plants. Yellow flag iris can spread by rhizome growth to form dense stands that can exclude even the toughest of our native wetland species, such as *Typha latifolia* (cattail). This noxious weed has already colonized the shoreline of the fragile fen system in LCR 28 and threatens to disperse further up into the wetland if not controlled. In addition to threatening to lower plant diversity, this noxious weed can also alter hydrologic dynamics through sediment accretion along the shoreline. Yellow flag iris has not yet been observed downstream at the Peterson Lake Park Natural Area (King County, 1999). This species produces prolific seed that could easily be transported downstream to invade this valuable resource area.

AQUATIC PLANT CONTROL ALTERNATIVES

This section outlines common methods used to control aquatic weeds. Much of the information in this section is quoted directly from the Ecology's website:

http://www.ecy.wa.gov/programs/wq/plants/management/index.html
Additional information is derived from the field experience of the King County Noxious Weed Control Program, in particular from Drew Kerr, Aquatic Noxious Weed Specialist and WSDA licensed aquatic herbicide applicator. Recommendations found in the 2001 draft version of the "King County Regional Milfoil Plan" have also been taken into consideration.

Control/eradication methods discussed herein include Aquatic Herbicide, Manual Methods, Bottom Screens, Diver Dredging, Biological Control, Rotovation, Cutting, Harvesting, and Drawdown.

AQUATIC HERBICIDES

Description of Method

http://www.ecy.wa.gov/programs/wq/plants/management/aqua028.html

Aquatic herbicides are chemicals specifically formulated for use in water to eradicate or control aquatic plants. Herbicides approved for aquatic use by the United States Environmental Protection Agency (EPA) have been reviewed and considered compatible with the aquatic environment when used according to label directions. However, individual states may also impose additional constraints on their use.

Aquatic herbicides are sprayed directly onto floating or emergent aquatic plants, or is applied to the water in either a liquid or pellet form. Systemic herbicides are capable of killing the entire plant by tranlocating from foliage or stems and killing the root. Contact herbicides cause the parts of the plant in contact with the herbicide to die back, leaving the roots alive and capable of re-growth (chemical mowing). Non-selective herbicides will generally affect all plants that they come in contact with, both monocots and dicots. Selective herbicides will affect only some plants (usually dicots – broad leafed plants like Eurasian watermilfoil will be affected by selective herbicides whereas monocots like Brazilian elodea and our native pondweeds may not be affected).

Because of environmental risks from improper application, aquatic herbicide use in Washington State waters is regulated and has certain restrictions. The Washington State Department of Agriculture must license aquatic applicators. In addition, because of a March 2001 court decision (Federal 9th Circuit District Court), coverage under a discharge permit called a National Pollutant Discharge Elimination System (NPDES) permit must be obtained before aquatic herbicides can be applied to some waters of the U.S. This ruling, referred to as the Talent Irrigation District decision, has further defined Section 402 of the Clean Water Act. Ecology has developed a general NPDES permit which is available for coverage under the Washington Department of Agriculture for the management of noxious weeds growing in an aquatic situation and a separate general permit for nuisance aquatic weeds (native plants) and algae control. For nuisance weeds (native species also referred to as beneficial vegetation) and algae, applicators and the local sponsor of the project must obtain a NPDES permit from the Washington Department of Ecology before applying herbicides to Washington water bodies.

Although there are a number of EPA registered aquatic herbicides, the Department of Ecology currently issues permits for four aquatic herbicides (as of 2002 treatment season). Several other herbicides are undergoing review and it is likely that other chemicals may be approved for use in Washington in the future. As an example, Renovate® (Triclopyr) has been approved by the U.S. EPA for aquatic use in November 2002, making it the first aquatic herbicide to receive registration since 1988. Renovate® was designed to be effective on both emergent and submersed plants. This herbicide formulation still needs to be evaluated by the Department of Ecology's Environmental Impact Statement (EIS) process before it can be approved for use in Washington. It should prove very effective on Eurasian watermilfoil, purple loosestrife, and yellow flag iris, and may be used on Spring Lake in future years once approved.

The chemicals that are currently permitted for use in 2002 are:

Aquatic Herbicides (see Appendix D for herbicide labels)

- **Rodeo® or Aquamaster®** - Active ingredient **glyphosate**. This systemic non-selective herbicide is used to control floating-leaved plants like water lilies and shoreline plants like purple loosestrife and yellow flag iris. It is generally applied as a liquid to the leaves. Rodeo® or Aquamaster® does not work on underwater plants such as Eurasian watermilfoil. Although glyphosate is a non-selective herbicide, a good applicator can somewhat selectively remove targeted plants by focusing the spray only on the plants to be removed. Plants take several weeks to die. A repeat application is often necessary to remove plants that were missed during the first application. Note: there are now other glyphosate products available, like Aquamaster®**,** with the exact formulation as Rodeo® but with different trade names now that the patent has expired. Additional surfactants are always added by the applicator for the aquatic formulations to improve the penetration of the leaf cuticle and help the herbicide stay on the plant long enough to be effective. Those that may be used for emergent weed control include X-77, LI-700, and R-11 as approved by the SEPA process. Only LI-700 is approved for fragrant water lily control under the NPDES permit.
- **2,4-D** – 2,4-D is a systemic, selective herbicide used for the control of Eurasian watermilfoil and other broad-leaved species.
    - **Navigate**® **and AquaKleen**® - Active ingredient **2,4-D BEE**. These granular products contain the low-volatile butoxyethyl-ester (BEE) formulation of 2,4-D. 2,4-D is a relatively fast acting selective, systemic herbicide. It is applied in a granular formulation and can be effective for spot treatment of Eurasian watermilfoil. When used at a rate of 100 pounds per acre, 2,4-D has shown to be selective to Eurasian watermilfoil, leaving native aquatic species relatively unaffected.
    - **DMA*4IVM**® - Dimethylamine Salt of **2,4-D**. This is a liquid formulation that is labeled for aquatic weed control. Since 2,4-D DMA (like 2,4-D BEE) is rapidly converted to 2,4-D acid, the two products should be equally effective in controlling Eurasian watermilfoil. Previously, 2,4-D DMA was only registered for this use in dams and reservoirs of the Tennessee Valley Authority (TVA) System, but is now approved for use in Washington and other states. It has recently been used to successfully control Eurasian watermilfoil in parts of Lake Washington, King County (Dorling, pers. comm.).
- **Sonar**® Active ingredient **fluridone**. Sonar® is a slow-acting systemic herbicide used to control Eurasian watermilfoil and other underwater plants. It may be applied in pelleted form or as a liquid. Fluridone can show good control of

submersed plants where there is little water movement and an extended time for the treatment. Its use is most applicable to whole-lake or isolated bay treatments where dilution can be minimized. It is not effective for spot treatments. It may take six to twelve weeks before the dying plants fall to the sediment and decompose. When used to manage Eurasian watermilfoil, Sonar® is applied several times during the summer to maintain a low, but consistent concentration in the water. Although fluridone is considered to be a non-selective herbicide, when used at low concentrations, it can be used to selectively remove Eurasian watermilfoil. Some native aquatic plants, especially pondweeds, are minimally affected by low concentrations of fluridone.

- **Aquathol**® - Active ingredient the dipotassium salt of **endothall**. Aquathol® is a fast-acting non-selective contact herbicide, which destroys the vegetative part of the plant but does not kill the roots. Aquathol® may be applied in a granular or liquid form. Generally endothall compounds are used primarily for short-term (one season) control of a variety of aquatic plants. However, there has been some recent research that indicates that when used in low concentrations, Aquathol® can be used to selectively remove exotic weeds, leaving some native species relatively unaffected. Because it is fast acting, Aquathol® can be used to treat smaller areas effectively. There are water use restrictions associated with the use of Aquathol® in Washington. Generally, most aquatic herbicides have use restrictions, with irrigation restrictions being the most common.

Advantages

- Aquatic herbicide application can be less expensive than other aquatic plant control methods.
- Aquatic herbicides are easily applied around docks and underwater obstructions.
- 2,4-D DMA & 2,4-D BEE have been shown to be effective in controlling smaller infestations (not lake-wide) of Eurasian watermilfoil in Washington, and could also be used on the purple loosestrife and yellow flag iris.
- Washington has had some success in eradicating Eurasian watermilfoil from some smaller lakes (320 acres or less) using Sonar®.
- Glyphosate is the recommended chemical for fragrant water lily control

Disadvantages

- Some herbicides have swimming, drinking, fishing, irrigation, and water use restrictions.
- Herbicide use may have unwanted impacts to people who use the water and to the environment.

- Non-targeted plants as well as nuisance plants may be controlled or killed by some herbicides.
- Depending on the herbicide used, it may take several days to weeks or several treatments during a growing season before the herbicide controls or kills treated plants.
- Rapid-acting herbicides like Aquathol® may cause low oxygen conditions to develop as plants decompose. Low oxygen can cause fish kills.
- To be most effective, generally herbicides must be applied to rapidly growing plants.
- Some expertise in using herbicides is necessary in order to be successful and to avoid unwanted impacts.
- Many people have strong feelings against using chemicals in water.
- Some cities or counties may have policies forbidding or discouraging the use of aquatic herbicides.

Permits

A NPDES permit is needed. Both the noxious and nuisance NPDES permits require the development of Integrated Aquatic Vegetation Management Plans (IAVMP) by the third year of control work. Monitoring of herbicide levels in the water is required starting in 2003, whether the chemical has been applied directly to the water or along the shoreline where it may have gotten into the adjacent water. For noxious weed control, the applicator must apply to the Washington Department of Agriculture (WSDA) for coverage under their NPDES permit each treatment season. There is no permit or application fee to obtain NPDES coverage under Agriculture's permit for Noxious Weeds. Since Spring Lake is in unincorporated King County, the King County Department of Development and Environmental Services (DDES) will require a permit for application of herbicide in Sensitive Areas to submergent, floating and emergent aquatic plants. This falls under their Clearing and Grading Permit.

Costs

Approximate costs for one-acre herbicide treatment (costs will vary from site to site):

- DMA*4IVM®: $500-700
- Navigate® and AquaKleen®: $500-700
- Rodeo® or Aquamaster® : $250
- Sonar®: $900 to $1,000

Other Considerations

The focus of the discussion below are the active ingredients 2,4-D and Glyphosate since the Steering Committee, with input from the watershed-wide public meetings, have chosen these two chemicals as the best options for the start of the Integrated Treatment Strategy (see pg. 55) for Spring Lake. Since fluridone (Sonar®) would have required a whole lake treatment and costs much more per unit than 2,4-D, it was not chosen as a viable option and is not discussed in further detail.

EPA studies yield the parameters LD_{50} (acute lethal dose to 50% of a test population), NOEL (No Observable Effect Level, which is the highest test dosage causing no adverse responses), and RfD (EPA Reference Dose determined by applying at least a 100-fold uncertainty factor to the NOEL). The EPA defines the RfD as the level that a human could be exposed to daily with reasonable certainty of no adverse effect from any cause, in other words, a "safe" dose. Exposures to bystanders or consumers are deemed safe when the RfD is not exceeded (Felsot, 1998). Since all substances, natural or manmade, may prove toxic at a sufficiently high dose, one should remember the old adage "dose makes the poison." The LD_{50} value is useful for comparing one compound with another and for grouping compounds into general hazard classes.

According to Felsot (1998), any pesticide, such as 2,4-D or glyphosate, that does not produce adverse effects on aquatic organisms until levels in water reach milligram per liter (i.e., mg/L, equivalent to a part per million, ppm) would be considered of comparatively low hazard. Substances that are biologically active in water at levels one-thousand-fold less, (i.e., μg/L, parts per billion, ppb), are considered highly hazardous to aquatic life. Most pesticides falling in the latter category are insecticides rather than herbicides.

Also, compounds that have half-lives less than 100 days are considered non-persistent compared to compounds having half-lives approaching one year or longer (for example, DDT). The half-life of 2,4-D is about 7 days in water, while that of glyphosate is about 12 days in water. Since there are multiple factors that modulate the pesticides' hazard, just focusing on the half-life itself is a bit misleading for hazard assessment. It is now known that the longer a residue remains in soil/sediment, the less likely it will be taken up by plants, leach, or runoff (Felsot, 1998). This phenomenon is called residue aging and involves changes in the forces governing interactions of the chemical with the soil matrix over time.

2,4-D

As far as restrictions for aquatic 2,4-D applications, there is no fishing restriction, and three to five days after treatment the water is generally below the drinking water standard (70ppb, irrigation standard is 100ppb for broad-leafed plants). Although 2,4-D should not damage grass or other monocots, it is not recommended that one use treated water to water lawns during this first three to five days since over-spray will kill ornamentals or plants such as tomatoes and grapes that are very sensitive to 2,4-D. There is no swimming restriction for 2,4-D use. Ecology advises that swimmers wait for 24 hours after application before swimming in the treatment area, but that is an advisory only. The choice is up to the individual.

Human and general mammalian health

The oral LD_{50} for 2,4-D (acid) is 764 mg/kg and the dermal LD_{50} is >2000 mg/kg. This chemical has a low acute toxicity (from an LD50 standpoint, is less toxic than caffeine and slightly more toxic than aspirin). The RfD for 2,4-D (acid) is 0.01 mg/kg/d. Recent, state-of-the-art EPA studies continue to find that it is not considered a carcinogen or mutagen, nor does it cause birth defects. It has a relatively short persistence in water, since it tends to bind to organic matter in the sediments. The herbicide 2,4-D generally does not bioaccumulate to a great extent, and the small amounts which do accumulate are rapidly eliminated once exposure ceases (Washington State Department of Ecology, 2001b).

The risks to human health from exposure to aquatic 2,4-D applications were evaluated in terms of the most likely forms of contact between humans and the water to which the herbicide was applied. Ecology's Risk Assessment results indicate that 2,4-D should present little or no risk to the public from acute (one time) exposures via dermal contact with the sediment, dermal contact with water (swimming), or ingestion of fish (Washington State Department of Ecology, 2001b). Based on the low dermal absorption of the chemical, the dose of 2,4-D received from skin contact with treated water is not considered significant. Dose levels used in studies are often far beyond what an animal or human would experience as a result of an aquatic application. Many experiments have examined the potential for contact by the herbicide applicator, although these concentrations have little relevance to environmental exposure by those not directly involved with the herbicide application. Once the herbicide has entered the water, its concentration will quickly decline because of turbulence associated mixing and dilution, volatilization, and degradation by sunlight and secondarily by microorganisms (Felsot, 1998).

Results of chronic exposure assessments indicate that human health should not be adversely impacted by chronic 2,4-D exposure via ingestion of fish, ingestion of surface water while swimming, incidental ingestion of sediments, dermal contact with sediments, or dermal contact with water (Washington State Department of Ecology, 2001b). Pharmacokinetic investigations have demonstrated that 2,4-D is rapidly absorbed from the gastrointestinal tract and is quickly excreted. Animal toxicological investigations carried out at high doses showed a reduction in the ability of the kidneys to excrete the chemical, and resulted in some systemic toxicity. However, the high doses tested may not be relevant to the typical low dose human exposures resulting from labeled use. A review of the scientific and medical literature failed to provide any human case reports of systemic toxicity or poisoning following overexposure to these herbicide products when used according to label instructions (Washington State Department of Ecology, 2001b). The risks to mammalian pets and wildlife should be closely related to these reported human risks, especially since many of the toxicity experiments are carried out on test animals by necessity.

The potential hazard to pregnant women and to the reproductive health of both men and women was evaluated. The results of the 2,4-D developmental or teratology (birth defects) and multigenerational reproduction studies indicate that the chemical is not considered to be a reproductive hazard or cause birth defects (teratogen) when administered below maternally toxic doses (Washington State Department of Ecology, 2001b). A review of the histopathological sections of various 2,4-D subchronic and chronic studies provides further support that the chemical does not affect the reproductive organs, except in some higher dose groups beyond the potential level of incidental exposure after an aquatic weed application.

Fish health

Based on laboratory data reported in the Department of Ecology's Risk Assessment of 2,4-D, 2,4-D DMA has a low acute toxicity to fish (LC_{50} ≥100 to 524 mg a.i./L for the rainbow trout and bluegill sunfish respectively). No Federally sensitive, threatened or endangered species were tested with 2,4-D DMA. However, it is likely that endangered salmonids would not exhibit higher toxic effects to 2,4-D DMA than those seen in rainbow trout. Since the maximum use rate of 2,4-D DMA would be no higher than the maximum labeled use rate (4.8 mg a.i./L) even the most sensitive fish species within the biota should not suffer adverse impacts from the effects of 2,4-D DMA. In conclusion, 2,4-D DMA will not effect fish or free-swimming invertebrate biota acutely or chronically when applied at typical use rates of 1.36 to 4.8 mg a.i./L (Washington State Dept. of Ecology, 2001b). However, more sensitive species of benthic invertebrates like glass shrimp may be affected by 2,4-D DMA, but 80 and 90% of the benthic species should be safe when exposed to 2,4-D DMA acutely or chronically at rates recommended on the label. Field work indicates that 2,4-D has no significant adverse impacts on fish, free-swimming invertebrates and benthic invertebrates, but well designed field studies are in short supply.

According to the Department of Ecology's Risk Assessment of 2,4-D, in the United States, 2,4-D BEE is the most common herbicide used to control aquatic weeds. 2,4-D BEE, has a high laboratory acute toxicity to fish (LC_{50} = 0.3 to 5.6 mg a.i./L for rainbow trout fry and fathead minnow fingerlings, respectively). Formal risk assessment indicates that short-term exposure to 2,4-D BEE should cause adverse impact to fish since the risk quotient is above the acute level of concern of 0.01 (RQ = 0.1 ppm/0.3 ppm = 0.33). However, the low solubility of 2,4-D BEE and its rapid hydrolysis to 2,4-D acid means fish are more likely to be exposed to the much less toxic 2,4-D acid. 2,4-D acid has a toxicity similar to 2,4-D DMA to fish (LC_{50} = 20 mg to 358 mg a.i./L for the common carp and rainbow trout, respectively). In contrast, formal risk assessment with 2,4-D acid indicates that short-term exposure to 2,4-D BEE should not cause adverse impact to fish since the risk quotient is below the federal level of concern of 0.01 (RQ = 0.1 ppm/20 ppm = 0.005). To conclude, 2,4-D BEE will have no significant impact on the animal biota acutely or chronically when using applied rates recommended on the label (Washington State Dept. of Ecology, 2001b). Although laboratory data indicates that 2,4-D BEE may be toxic to fish, free-swimming invertebrates and benthic invertebrates, data indicates that its toxic potential is not realized under typical concentrations and conditions found in the field. This lack of field toxicity is likely due to the low solubility of 2,4-D BEE and its rapid hydrolysis to the practically non-toxic 2,4-D acid within a few hours to a day following the application.

Glyphosate

Examination of mammalian toxicity has shown that the acute oral and dermal toxicity of glyphosate would fall into EPA's toxicity category III. This category characterizes slightly to moderately toxic compounds. Glyphosate is practically nontoxic by ingestion, with a reported acute oral LD_{50} of 5600 mg/kg in tested rats. The risks of incidental contact from swimming in treated water have also been judged as low with a dermal LD_{50} of 7940 mg/kg, a very high threshold. The RfD for glyphosate is 0.1 mg/kg/d. To place the level of hazard to humans in perspective, the commonly consumed chemicals caffeine (present in coffee, tea, and certain soft drinks), aspirin (acetylsalicylic acid), and nicotine (the neuroactive ingredient in tobacco) have acute oral LD_{50}'s of 192, 1683, and 53 mg/kg, respectively. Thus, the herbicides for the most part are comparatively less toxic than chemicals to which consumers voluntarily expose themselves (Felsot, 1998).

Since the shikimic acid pathway does not exist in animals, the acute toxicity of glyphosate is very low. Animal studies, which the Environmental Protection Agency has evaluated in support of the registration of glyphosate, can be used to make inferences relative to human health. The U.S. Forest Service's glyphosate fact sheet reports that the EPA has concluded that glyphosate should be classified as a compound with evidence of non-carcinogenicity for humans (Information Ventures, Inc.). This conclusion is based on the lack of convincing carcinogenicity evidence in adequate studies in two animal species. Laboratory studies on glyphosate using pregnant rats (dose levels up to 3500 mg/kg per day) and rabbits (dose levels up to 350 mg/kg per day), indicated no evidence of teratology (birth defects). A three-generation reproduction study in rats did not show any adverse effects on fertility or reproduction at doses up to 30 mg/kg per day. Glyphosate was negative in all tests for mutagenicity (the ability to cause genetic damage).

Technically, glyphosate acid is practically nontoxic to fish and may be slightly toxic to aquatic invertebrates (EXTOXNET, 1996). Some formulations may be more toxic to fish and aquatic species due to differences in toxicity between the salts and the parent acid, or to surfactants used in the formulation. There is a very low potential for the compound to build up in the tissues of aquatic invertebrates or other aquatic organisms. In water, glyphosate is strongly adsorbed to suspended organic and mineral matter and is broken down primarily by microorganisms.

In relation to shoreline applications, glyphosate is moderately persistent in soil, with an estimated average half-life of 47 days. It is strongly adsorbed to most soils, even those with lower organic and clay content. Thus, even though it is highly soluble in water, field and laboratory studies show it does not leach appreciably, and has low potential for runoff (except as adsorbed to colloidal matter). One estimate indicated that less than 2% of the applied chemical is lost to runoff (Malik et. al., 1989). Microbes are primarily responsible for the breakdown of the product, and volatilization or photodegradation losses will be negligible.

The manufacturer of Rodeo®, one of the aquatic formulations of glyphosate, recommends use of a nonionic surfactant with all applications to improve efficacy. Of the approved surfactants for aquatic use in Washington, only LI-700 (Loveland Industries, Inc.) may be used for fragrant water lily control and will therefore be applied directly to the water. Based on the results of searches of the published literature and the Toxic Substances Control Act Test Submission (TSCATS) database, little data are available regarding the toxicity of the surfactant formulations (Diamond & Durkin, 1997). The oral LD_{50} was >5000 and 5900 mg/kg in male and female rats, respectively, and the dermal LD_{50} for a 24-hour exposure was >5000 mg/kg in rabbits. These values are in the same range as glyphosate alone, EPA's toxicity category III, which puts LI-700 in a category of lower risk to mammals.

Suitability for Spring Lake

Aquatic herbicides can provide an effective method for control and eventual eradication of noxious weeds. The use of a formulation of 2,4-D should provide excellent initial control of the Eurasian watermilfoil while allowing for the more-appropriate spot treatments in this scattered infestation. We should be able to avoid an expensive, lake-wide treatment with fluridone for control of Eurasian watermilfoil.

The loose sediments in Spring Lake are high in organic content and are flocculent around much of the lake's littoral zone. There is some concern that the granular formulations of 2,4-D BEE found in Navigate**®** and AquaKleen**®** may settle by gravity into these sediments, which could inhibit the release of the 2,4-D to the water column. Obviously, if this was the case, we may not achieve the predicted level of control of Eurasian watermilfoil because the concentrations released to the water column may not be high enough to kill the plants. Since the liquid formulation 2,4-D DMA is now available for use in Washington State, this may provide better control than the granular formulation. The 2,4-D DMA also carries with it the reduced acute toxicity reported above, which could mitigate any potential harm to fish and their food web. The cost of 2,4-D DMA is about the same as 2,4-D BEE, so there are no cost considerations. In addition, work in 2002 with 2,4-D DMA in Lake Washington resulted in excellent control of milfoil with almost no regrowth (D. Dorling, pers. comm.). Spring Lake does not appear to have anadromous salmonids, but Tributary 0328 does receive use by Coho salmon. Neither formulation of the herbicide (2,4-D BEE or 2,4-D DMA) should have any downstream effects since the rapid hydrolysis to 2,4-D acid produces a chemical that is practically non-toxic.

Glyphosate should be very effective on the other target species: purple loosestrife, fragrant water lily, and yellow flag iris. Westerdahl and Getsinger (1988) report excellent control of the fragrant water lily with glyphosate. Generally glyphosate is the recommended herbicide for water lily control because it can be applied directly to the floating leaves, unlike fluridone or endothall which must be applied to the water. The application of glyphosate allows specific plants or areas of plants to be targeted for removal. Generally two applications of glyphosate are needed. The second application later in the summer controls the plants that were missed during the first herbicide application. The control effectiveness of fragrant water lily is easy to measure through visual surveys due to the floating leaves.

Glyphosate should provide excellent systemic control of mature purple loosestrife plants and seedlings. This herbicide is very effective on purple loosestrife and we can expect better than 70-80% control on existing plants after Year 1. Seeds of purple loosestrife can remain viable for three years in the laboratory, but may remain viable for a much shorter time in the natural environment (Washington State Noxious Weed Control Board, 1997). Therefore, the existing mature plants and seedbank may be exhausted within the time frame of the project. Finally, Glyphosate should also provide excellent systemic control of yellow flag iris. This species has an abundant leaf surface area to absorb the chemical for translocation to the rhizome. The use of an herbicide will enable the elimination of the mature plants without potentially destructive disturbance of the shoreline by excavation. The herbicide used for milfoil control, 2,4-D, may also be an effective alternative for the purple loosestrife and yellow flag iris control efforts. However, this chemical is more expensive, so an evaluation of the effectiveness of glyphosate on these species will determine whether a change in herbicide would be beneficial.

One of the main reasons to eradicate milfoil and fragrant water lily is to maintain the health of the native aquatic plant community for all of the species that utilize them in their life cycles, as well as to maintain the viability of the lake for human recreational uses. The nature of the control methods to be implemented will minimize impacts to native aquatic vegetation. The control of the Eurasian watermilfoil and fragrant water lily will be conducted by methods designed to preserve (and eventually enhance or conserve) the native plant communities. Herbicide selective to Eurasian watermilfoil will be used for its control and will not require a whole-lake treatment that would expose all the submersed plants to the herbicide. The herbicide for the fragrant water lily will be applied to the floating leaves, and therefore should be easily focused to kill only the target vegetation. Follow-up control methods (diver hand pulling and/or diver dredging) will focus specifically on these two target species and should also leave beneficial plants intact. With these constraints in place, conservation areas should not need to be established to serve vital ecosystem functions until native plants re-establish. The application of herbicide to the emergent species (purple loosestrife and yellow flag iris) will also be conducted by manual spot applications. An experienced herbicide applicator can selectively target individual weed species and limit collateral damage to other species to a minimum. This is especially true when infestations are small so that large areas with a diverse plant distribution don't have to be treated. Since the emergent noxious weed infestations at Spring Lake are still confined largely to the shoreline, it should be relatively simple for the control applicator to avoid collateral damage and preserve the native plant community.

We do not anticipate any need to revegetate after controlling the milfoil and fragrant water lily since only about 23% of the lake is currently colonized with aquatic plants. In the terrestrial environment in the Pacific Northwest, bare ground will often be colonized rapidly by invasive species, but this is not usually a problem in lacustrine areas. A drawback of using herbicides is the "uplifting" of mats of decomposing water lily roots that can form large floating islands in the waterbody after the herbicides have killed the plants. Most of the water lilies are in small, discrete circular patches as opposed to large monospecific stands. These smaller areas may not generate floating sediment mats because of their size, but there are several places in Spring Lake with a larger area covered with fragrant water lily. Volunteers from the community will remove any sediment mats created in these areas, for which we will need to get Hydraulic Project Approval from Washington Fish & Wildlife. For smaller mats, we may tow them to shore and remove the sediment with hand tools. If larger mats occur, we will have to investigate machinery mounted on a barge to dig or dredge out the sediment mat.

Past community efforts at Spring Lake have used aquatic herbicides, so we do not anticipate disagreement with this recommendation from the community. Initial support has been documented in the form of signatures on a Letter of Support distributed after the second watershed-wide meeting on September 19, 2002.

Many of the residences on Spring Lake have water rights, although finding a comprehensive list of water right holders has proven difficult. For a list of know water rights, refer to Appendix E. To ensure that all residents who might draw water from the lake are aware of water use restrictions, there will be announcements sent to all lakeside residents prior to each herbicide treatment. One announcement will be sent at the beginning of the summer with approximate dates of planned treatments, and subsequent announcements will be sent 7-10 days prior to each treatment, with exact dates of treatment and use restrictions.

MANUAL METHODS

Hand-Pulling

Hand-pulling aquatic plants is similar to pulling weeds out of a garden. It involves removing entire plants (leaves, stems, and roots) from the area of concern and disposing of them in an area away from the shoreline. In water less than three feet deep no specialized equipment is required, although a spade, trowel, or long knife may be needed if the sediment is packed or heavy. In deeper water, hand pulling is best accomplished by divers with SCUBA equipment and mesh bags for the collection of plant fragments. Some sites may not be suitable for hand pulling such as areas where deep flocculent sediments may cause a person hand pulling to sink deeply into the sediment.

Cutting

Cutting differs from hand pulling in that plants are cut and the roots are not removed. Cutting is performed by standing on a dock or on shore and throwing a cutting tool out into the water. A non-mechanical aquatic weed cutter is commercially available. Two single-sided, razor sharp stainless steel blades forming a "V" shape are connected to a handle, which is tied to a long rope. The cutter can be thrown about 20 – 30 feet into the water. As the cutter is pulled through the water, it cuts a 48-inch wide swath. Cut plants rise to the surface where they can be removed. Washington State requires that cut plants be removed from the water. The stainless steel blades that form the V are extremely sharp and great care must be taken with this implement. It should be stored in a secure area where children do not have access.

Raking

A sturdy rake makes a useful tool for removing aquatic plants. Attaching a rope to the rake allows removal of a greater area of weeds. Raking literally tears plants from the sediment, breaking some plants off and removing some roots as well. Specially designed aquatic plant rakes are available. Rakes can be equipped with floats to allow easier plant and fragment collection. The operator should pull towards the shore because a substantial amount of plant material can be collected in a short distance.

Cleanup

All of the manual control methods create plant fragments. It's important to remove all fragments from the water to prevent them from re-rooting or drifting onshore. Plants and fragments can be composted or added directly to a garden.

Advantages

- Manual methods are easy to use around docks and swimming areas.
- The equipment is inexpensive.
- Hand-pulling allows the flexibility to remove undesirable aquatic plants while leaving desirable plants.
- These methods are environmentally safe.
- Manual methods don't require expensive permits, and can be performed on aquatic noxious weeds with Hydraulic Project Approval obtained by reading and following the pamphlet *Aquatic Plants and Fish* (publication #APF-1-98) available from the Washington Department of Fish & Wildlife

Disadvantages

- As plants re-grow or fragments re-colonize the cleared area, the treatment may need to be repeated several times each summer.
- Because these methods are labor intensive, they may not be practical for large areas or for thick weed beds.
- Even with the best containment efforts, it is difficult to collect all plant fragments, leading to re-colonization.
- Some plants, like water lilies which have massive rhizomes, are difficult to remove by hand pulling.

- Pulling weeds and raking stirs up the sediment and makes it difficult to see remaining plants. Sediment re-suspension can also increase nutrient levels in lake water.
- Hand pulling and raking impacts bottom-dwelling animals.
- The V-shaped cutting tool is extremely sharp and can be dangerous to use.

Permits

Permits are required for many types of manual projects in lakes and streams. The Washington State Department of Fish and Wildlife requires a *Hydraulic Project Approval* permit for all activities taking place in the water including hand pulling, raking, and cutting of aquatic plants.

Costs

- Hand-pulling costs up to $130 for the average waterfront lot for a hired commercial puller.
- A commercial grade weed cutter costs about $130 with accessories. A commercial rake costs about $95 to $125. A homemade weed rake costs about $85 (asphalt rake is about $75 and the rope costs 35-75 cents per foot).

Other Considerations

Does community want to invest in weed rakes, other equipment?

Manual methods must include regular scheduled surveys to determine the extent of the remaining weeds and/or the appearance of new plants after eradication has been attained

Suitability for Spring Lake

- These methods will be important beginning at the end of Year 1, after the chemical control methods have been evaluated for their effectiveness. At this point, diver hand-pulling should be sufficient to remove all of the remaining Eurasian watermilfoil plants.
- Manual methods will also be vital in combating new infestations of Eurasian watermilfoil in subsequent years, especially around the boat launch
- The currently infested areas are too large (and will be even bigger summer 2003) to use manual techniques as the sole source of control for Eurasian watermilfoil and fragrant water lily. Costs would be much higher than for an integrated approach.
- Manual methods have the potential for missing Eurasian watermilfoil plants, especially after stirring up sediments.
- Manual methods have the potential for fragmentation, exacerbating the existing Eurasian watermilfoil problem

- Cutting can be used to control small areas of fragrant water lily, especially those close to the shoreline. Using this method out in the open water would require a stable boat (not canoe) and great care not to injure oneself or another passenger. Since repeated cutting over several seasons may be required to starve the roots, this would fit best as a supplement to other control methods.
- Many landowners have already been manually removing their loosestrife for several seasons. This does not kill the mature perennial plants, but does halt seed production and can contain the infestation at current levels. If done repeatedly over several seasons it should starve the roots and kill the plants.
- Many of the purple loosestrife plants, especially along the fen, have been weakened by repeated cutting several times a season but continue to flower each year. Access to these plants requires traversing mud flat areas and trampling of wetland vegetation. In the short term, areas bounce back from these impacts, but repeated access can create permanent damage to complete the manual control efforts.
- Manual removal of seedlings (pulling) of purple loosestrife is much easier than the removal of well-rooted, mature plants. This technique can be used to exhaust the seed bank and supplement other eradication efforts.
- Manual efforts are much more difficult on yellow flag iris since the plants don’t emerge from simple stems that can be cut, and they arise from massive rhizomes inhibiting pulling or digging. The area is also dangerous for volunteers due to the deep muck along the lakeshore. The area south of the boat launch at the north end of LCR 28 has an especially heavy concentration of yellow flag iris. There is a large amount of root mass associated with the iris in this area that would take a significant effort to remove by excavation, while potentially disturbing part of the fen plant communities. This would also expose the face of the peatland, which could contribute to desiccation and disintegration of the fen edge. This could lead to water quality problems.

DIVER DREDGING

Diver dredging (suction dredging) is a method whereby SCUBA divers use hoses attached to small dredges (often dredges used by miners for mining gold from streams) to suck plant material from the sediment. The purpose of diver dredging is to remove all parts of the plant including the roots. A good operator can accurately remove target plants, like Eurasian watermilfoil, while leaving native species untouched. The suction hose pumps the plant material and the sediments to the surface where they are deposited into a screened basket. The water and sediment are returned back to the water column (if the permit allows this), and the plant material is retained. The turbid water is generally discharged to an area curtained off from the rest of the lake by a silt curtain. The plants are disposed of on shore. Removal rates vary from approximately 0.25 acres per day to one acre per day depending on plant density, sediment type, size of team, and diver efficiency. Diver dredging is more effective in areas where softer sediment allows easy removal of the entire plants, although water turbidity is increased with softer sediments.

Harder sediment may require the use of a knife or tool to help loosen sediment from around the roots. In very hard sediments, milfoil plants tend to break off leaving the roots behind and defeating the purpose of diver dredging.

Diver dredging has been used in British Columbia, Washington, and Idaho to remove early infestations of Eurasian watermilfoil [site source]. In a large-scale operation in western Washington, two years of diver dredging reduced the population of milfoil by 80 percent (Silver Lake, Everett). Diver dredging is less effective on plants where seeds, turions, or tubers remain in the sediments to sprout the next growing season. For that reason, Eurasian watermilfoil is generally the target plant for removal during diver dredging operations.

Advantages

- Diver dredging can be a very selective technique for removing pioneer colonies of Eurasian watermilfoil.
- Divers can remove plants around docks and in other difficult to reach areas.
- Diver dredging can be used in situations where herbicide use is not an option for aquatic plant management.

Disadvantages

- Diver dredging is very expensive.
- Dredging stirs up large amounts of sediment. This may lead to the release of nutrients or long-buried toxic materials into the water column.
- Only the tops of plants growing in rocky or hard sediments may be removed, leaving a viable root crown behind to initiate growth.
- In some states, acquisition of permits can take years.

Permits

Permits are required for many types of projects in lakes and streams. Diver dredging requires Hydraulic Approval from the Department of Fish and Wildlife. Check with your city or county for any local requirements before proceeding with a diver-dredging project. Also diver dredging may require a Section 404 permit from the U.S. Army Corps of Engineers.

Costs

Depending on the density of the plants, specific equipment used, number of divers and disposal requirements, costs can range from a minimum of $1,500 to $2,000 per day.

Other Considerations

- Might be good spot control method in subsequent years (coordinated with diver survey)

Suitability for Spring Lake

- As with diver hand pulling, diver dredging could be used after the initial herbicide applications to remove plants that were missed or unaffected by the herbicide. The soft organic sediments in Spring Lake should make this method effective. However, permit costs may warrant having this work done as diver hand pulling since the roots should be largely removed from the loose sediments without the need for dredging.
- Diver dredging greatly disturbs sediments and can affect nutrient concentrations and algal production in the lake (see Disadvantages above). If other techniques of for removal are suitable, this should not be considered.

BOTTOM SCREENS

A bottom screen or benthic barrier covers the sediment like a blanket, compressing aquatic plants while reducing or blocking light. Materials such as burlap, plastics, perforated black Mylar, and woven synthetics can all be used as bottom screens. Some people report success using pond liner materials. There is also a commercial bottom screen fabric called Texel, a heavy, felt-like polyester material, which is specifically designed for aquatic plant control.

An ideal bottom screen should be durable, heavier than water, reduce or block light, prevent plants from growing into and under the fabric, be easy to install and maintain, and should readily allow gases produced by rotting weeds to escape without “ballooning” the fabric upwards.

Even the most porous materials, such as window screen, will billow due to gas buildup. Therefore, it is very important to anchor the bottom barrier securely to the bottom. Unsecured screens can create navigation hazards and are dangerous to swimmers. Anchors must be effective in keeping the material down and must be regularly checked. Natural materials such as rocks or sandbags are preferred as anchors.

The duration of weed control depends on the rate that weeds can grow through or on top of the bottom screen, the rate that new sediment is deposited on the barrier, and the durability and longevity of the material. For example, burlap may rot within two years, plants can grow through window screening material, and can grow on top of felt-like Texel fabric. Regular maintenance is essential and can extend the life of most bottom barriers.

Bottom screens will control most aquatic plants, however freely-floating species such as the bladderworts or coontail will not be controlled by bottom screens. Plants like Eurasian watermilfoil will send out lateral surface shoots and may canopy over the area that has been screened giving less than adequate control.

In addition to controlling nuisance weeds around docks and in swimming beaches, bottom screening has become an important tool to help eradicate and contain early infestations of noxious weeds such as Eurasian watermilfoil and Brazilian elodea. Pioneering colonies that are too extensive to be hand pulled can sometimes be covered with bottom screening material. For these projects, we suggest using burlap with rocks or burlap sandbags for anchors. By the time the material decomposes, the milfoil patches will be dead as long as all plants were completely covered. Snohomish County staff reported native aquatic plants colonizing burlap areas that covered pioneering patches of Eurasian watermilfoil. When using this technique for Eurasian watermilfoil eradication projects, divers should recheck the screen within a few weeks to make sure that all milfoil plants remain covered and that no new fragments have taken root nearby.

Bottom screens can be installed by the homeowner or by a commercial plant control specialist. Installation is easier in winter or early spring when plants have died back. In summer, cutting or hand pulling the plants first will facilitate bottom screen installation. Research has shown that much more gas is produced under bottom screens that are installed over the top of aquatic plants. The less plant material that is present before installing the screen, the more successful the screen will be in staying in place. Bottom screens may also be attached to frames rather than placed directly onto the sediment. The frames may then be moved for control of a larger area (see instructions for constructing and installing bottom screens).

Advantages

- Installation of a bottom screen creates an immediate open area of water.
- Bottom screens are easily installed around docks and in swimming areas.
- Properly installed bottom screens can control up to 100 percent of aquatic plants.
- Screen materials are readily available and can be installed by homeowners or by divers.

Disadvantages

- Because bottom screens reduce habitat by covering the sediment, they are suitable only for localized control.
- For safety and performance reasons, bottom screens must be regularly inspected and maintained.
- Harvesters, rotovators, fishing gear, propeller backwash, or boat anchors may damage or dislodge bottom screens.
- Improperly anchored bottom screens may create safety hazards for boaters and swimmers.
- Swimmers may be injured by poorly maintained anchors used to pin bottom screens to the sediment.
- Some bottom screens are difficult to anchor on deep muck sediments.
- Bottom screens interfere with fish spawning and bottom-dwelling animals.
- Without regular maintenance aquatic plants may quickly colonize the bottom screen.

Permits

Bottom screening in Washington requires hydraulic approval, obtained free from the Department of Fish and Wildlife. Check with your local jurisdiction to determine whether a shoreline permit is required.

Costs

Barrier materials cost $0.22 to $1.25 per square foot. The cost of some commercial barriers includes an installation fee.

Commercial installation costs vary depending on sediment characteristics and type of bottom screen selected. It costs up to about $750 to have 1,000 square feet of bottom screen installed. Maintenance costs for a waterfront lot are about $120 each year.

Other Considerations

- None

Suitability for Spring Lake

- The Eurasian watermilfoil infestation at Spring Lake is too advanced to consider this method for large-scale eradication.
- Most of the lakeshore residences have only small infestations and the bottom barrier would just reduce habitat by covering the sediment.
- Infested areas are too scattered or are too large to use a bottom barrier without becoming cost prohibitive.
- Barriers could be effective at the boat ramp to prevent re-infestation after initial control, or in areas that have dense milfoil and have shown resistance to the herbicide. We plan to install a bottom barrier at the boat launch to provide these benefits.
- Since there is not a swimming beach at Spring Lake, the boat launch seems the only appropriate place to install a bottom barrier to enhance the recreational potential of the lake.

BIOLOGICAL CONTROL

General Overview

Many problematic aquatic plants in the western United States are non-indigenous species. Plants like Eurasian watermilfoil, Brazilian elodea, and purple loosestrife have been introduced to North America from other continents. Here they grow extremely aggressively, forming monocultures that exclude native aquatic plants and degrade fish and wildlife habitat. Yet, often these same species are not aggressive or invasive in their native range. This may be in part because their populations are kept under control by insects, diseases, or other factors not found in areas new to them.

The biological control of aquatic plants focuses on the selection and introduction of other organisms that have an impact on the growth or reproduction of a target plant, usually from their native ranges. Theoretically, by stocking an infested waterbody or wetland with these organisms, the target plant can be controlled and native plants can recover.

Classic biological control uses control agents that are host specific. These organisms attack only the species targeted for control. Generally these biocontrol agents are found in the native range of the nuisance aquatic plants and, like the targeted plant, these biocontrol agents are also non-indigenous species. With classic biological control an exotic species is introduced to control another exotic species. However, extensive research must be conducted before release to ensure that biological control agents are host specific and will not harm the environment in other ways. The authors of *Biological Control of Weeds – A World Catalogue of Agents and Their Target Weeds* state that after 100 years of using biocontrol agents, there are only eight examples, world-wide, of damage to non-target plants, "none of which has caused serious economic or environmental damage…".

Search for a classical biological control agent typically starts in the region of the world that is home to the nuisance aquatic plant. Researchers collect and rear insects and/or pathogens that appear to have an impact on the growth or reproduction of the target species. Those insects/pathogens that appear to be generalists (feeding or impacting other aquatic plant species) are rejected as biological control agents. Insects that impact the target species (or very closely related species) exclusively are considered for release.

Once collected, these insects are reared and tested for host specificity and other parameters. Only extensively researched, host-specific organisms are cleared by the United States for release. It generally takes a number of years of study and specific testing before a biological control agent is approved.

Even with an approved host-specific bio-control agent, control can be difficult to achieve. Some biological control organisms are very successful in controlling exotic species and others are of little value. A number of factors come into play. It is sometimes difficult to establish reproducing populations of a bio-control agent. The ease of collection of the biocontrol and placement on the target species can also have a role in the effectiveness. Climate or other factors may prevent its establishment, with some species not proving capable of over-wintering in their new setting. Sometimes the bio-control insects become prey for native predator species, and sometimes the impact of the insect on the target plant just isn't enough to control the growth and reproduction of the species.

People who work in this field say that the more biological control species that you can put to work on a problem plant, the better success you will have in controlling the targeted species. There are some good examples where numerous biological control agents have had little effect on a targeted species, and other examples where one bio-control agent was responsible for the complete control of a problem species.

However, even when biological control works, a classic biological control agent generally does not totally eliminate all target plants. A predator-prey cycle establishes where increasing predator populations will reduce the targeted species. In response to decreased food supply (the target plant is the sole food source for the predator), the predator species will decline. The target plant species rebounds due to the decline of the predator species. The cycle continues with the predator populations building in response to an increased food supply.

Although a successful biological control agent rarely eradicates a problem species, it can reduce populations substantially, allowing native species to return. Used in an integrated approach with other control techniques, biological agents can stress target plants making them more susceptible to other control methods.

A number of exotic aquatic species have approved classic biological control agents available for release in the US. These species include Hydrilla, water hyacinth, alligator weed, and purple loosestrife.

In 1992 three beetles were released in Washington for purple loosestrife control. Their damaging impact on purple loosestrife populations was evident in the Winchester Wasteway area of Grant County in 1996. In 1998, 1999, and 2000, the Washington State Noxious Weed Control Board organized insect collection for state, local, and federal staff. Thousands of insects were collected and distributed to purple loosestrife sites throughout the state and even the United States. The King County Noxious Weed Control Program has placed *Galerucella* sp. from the Winchester Wasteway on a number of purple loosestrife sites. These sites were chosen because of a high density of the target plant and the fact that other control methods were impractical. The sites were in complex wetland habitats with a high presence of native vegetation that would be damaged by chemical applications or repeated foot traffic through the wetland to implement manual control methods.

Another type of biological control uses **general agents** such as grass carp (see below) to manage problem plants. Unlike classical bio-control agents, these fish are not host specific and will not target specific species. Although grass carp do have food preferences, under some circumstances, they can eliminate all submersed vegetation in a waterbody. Like classic biological control agents, grass carp are exotic species and originate from Asia. In Washington, all grass carp must be certified sterile before they can be imported into the state. There are many waterbodies in Washington (mostly smaller sites) where grass carp are being used to control the growth of aquatic plants.

During the past decade a third type of control agent has emerged. In this case, a native insect that feeds and reproduces on northern milfoil (*Myriophyllum sibericum*) which is native to North America, was found to also utilize the non-native Eurasian watermilfoil (*Myriophyllum spicatum*). Vermont government scientists first noticed that Eurasian watermilfoil had declined in some lakes and brought this to the attention of researchers. It was discovered that a native watermilfoil weevil (*Euhrychiopsis lecontei)* feeding on Eurasian watermilfoil caused the stems to collapse. Because native milfoil has thicker stems than Eurasian watermilfoil, the mining activity of the larvae does not cause it the same kind of damage. A number of declines of Eurasian watermilfoil have been documented around the United States and researchers believe that weevils may be implicated in many of these declines.

Several researchers around the United States (Vermont, Minnesota, Wisconsin, Ohio, & Washington) have been working to determine the suitability of this insect as a bio-control agent. The University of Washington is conducting research into the suitability of the milfoil weevil for the biological control of milfoil in Washington lakes and rivers. Surveys have shown that in Washington the weevil is found more often in eastern Washington lakes and it seems to prefer more alkaline waters. However, it is also present in cooler, wetter western Washington. The most likely candidates for use as biological controls are discussed in the following section.

Grass Carp

http://www.ecy.wa.gov/programs/wq/plants/management/aqua024.html

The grass carp (*Cteno pharynogodon)*, also known as the white amur, is a vegetarian fish native to the Amur River in Asia. Because this fish feeds on aquatic plants, it can be used as a biological tool to control nuisance aquatic plant growth. In some situations, sterile (triploid) grass carp may be permitted for introduction into Washington waters.

Permits are most readily obtained if the lake or pond is privately owned, has no inlet or outlet, and is fairly small. The objective of using grass carp to control aquatic plant growth is to end up with a lake that has about 20 to 40 percent plant cover, not a lake devoid of plants. In practice, grass carp often fail to control the plants, or in cases of overstocking, all the submersed plants are eliminated from the waterbody.

The Washington Department of Fish and Wildlife determines the appropriate stocking rate for each waterbody when they issue the grass carp-stocking permit. Stocking rates for Washington lakes generally range from 9 to 25 eight- to eleven-inch fish per vegetated acre. This number will depend on the amount and type of plants in the lake as well as spring and summer water temperatures. To prevent stocked grass carp from migrating out of the lake and into streams and rivers, all inlets and outlets to the pond or lake must be screened. For this reason, residents on waterbodies that support a salmon or steelhead run are rarely allowed to stock grass carp into these systems.

Once grass carp are stocked in a lake, it may take from two to five years for them to control nuisance plants. Survival rates of the fish will vary depending on factors like presence of otters, birds of prey, or fish disease. A lake will probably need restocking about every ten years.

Success with grass carp in Washington has been varied. Sometimes the same stocking rate results in no control, control, or even complete elimination of all underwater plants. Bonar *et. Al*. Found that only 18 percent of 98 Washington lakes stocked with grass carp at a median level of 24 fish per vegetated acre had aquatic plants controlled to an intermediate level. In 39 percent of the lakes, all submersed plant species were eradicated. It has become the consensus among researchers and aquatic plant managers around the country that grass carp are an all or nothing control option. They should be stocked only in waterbodies where complete elimination of all submersed plant species can be tolerated.

Grass carp exhibit definite food preferences and some aquatic plant species will be consumed more readily than others. Pauley and Bonar performed experiments to evaluate the importance of 20 Pacific Northwest aquatic plant species as food items for grass carp. Grass carp did not remove plants in a preferred species-by-species sequence in multi-species plant communities. Instead they grazed simultaneously on palatable plants of similar preference before gradually switching to less preferred groups of plants. The relative preference of many plants was dependent upon what other plants were associated with them. The relative preference rank for the 20 aquatic plants tested was as follows: *Potamogeton crispus* (curly leaf pondweed) = *P. pectinatus* (sago pondweed) > *P. zosteriformes* (flat-stemmed pondweed) > *Chara* sp.(muskgrasses) = *Elodea canadensis* (American waterweed) = thin-leaved pondweeds *Potamogeton* spp. > *Egeria densa* (Brazilian elodea) (large fish only) > *P. praelongus* (white-stemmed pondweed) = *Vallisneria americana* (water celery) > ***Myriophyllum spicatum* (Eurasian watermilfoil)** > *Ceratophyllum demersum* (coontail) >*Utricularia vulgaris* (bladderwort) > *Polygonum amphibium* (water smartweed) > *P. natans* (floating leaved pondweed) > *P. amplifolius* (big leaf pondweed) > *Brasenia schreberi* (watershield) = *Juncus* sp.(rush) > *Egeria densa* (Brazilian elodea) (fingerling fish only) > *Nymphaea* sp. (fragrant water lily) > *Typha* sp. (cattail) > *Nuphar* sp. (spatterdock).

Generally in Washington, grass carp do not consume emergent wetland vegetation or water lilies even when the waterbody is heavily stocked or over stocked. A heavy stocking rate of triploid grass carp in Chambers Lake, Thurston County resulted in the loss of most submersed species, whereas the fragrant water lilies, bog bean, and spatterdock remained at pre-stocking levels. A stocking of 83,000 triploid grass carp into Silver Lake Washington resulted in the total eradication of all submersed species, including Eurasian watermilfoil, Brazilian elodea, and swollen bladderwort. However, the extensive wetlands surrounding Silver Lake have generally remained intact. In southern states, grass carp have been shown to consume some emergent vegetation (Washington State Department of Ecology, 2002).

Grass carp stocked into Washington lakes must be certified disease free and sterile. Sterile fish, called triploids because they have an extra chromosome, are created when the fish eggs are subjected to a temperature or pressure shock. Fish are verified sterile by collecting and testing a blood sample. Triploid fish have slightly larger blood cells and can be differentiated from diploid (fertile) fish by this characteristic. Grass carp imported into Washington must be tested to ensure that they are sterile.

Because Washington does not allow fertile fish within the state, all grass carp are imported into Washington from out of state locations. Most grass carp farms are located in the southern United States where warmer weather allows for fast fish growth rates. Large shipments are transported in special trucks and small shipments arrive via air.

Here are some facts about grass carp:

- Are only distantly related to the undesirable European carp, and share few of its habits.
- Generally live for at least ten years and possibly much longer in Washington State waters.

- Will grow rapidly and reach at least ten pounds. They have been known to reach 40 pounds in the southern United States.
- Feed only on plants at the age they are stocked into Washington waters.
- Will not eat fish eggs, young fish or invertebrates, although baby grass carp are omnivorous.
- Feed from the top of the plant down so that mud is not stirred up. However, in ponds and lakes where grass carp have eliminated all submersed vegetation the water becomes turbid. Hungry fish will eat organic material out of the sediments.
- Have definite taste preferences. Plants like Eurasian milfoil and coontail are **not** preferred. American waterweed and thin leaved pondweeds are preferred. Water lilies are rarely consumed in Washington waters.
- Are dormant during the winter. Intensive feeding starts when water temperatures reach 68^{o} F.
- Prefer flowing water to still waters (original habitat is fluvial).
- Are difficult to recapture once released.
- They may not feed in swimming areas, docks, boating areas, or other sites where there is heavy human activity.

Advantages

- Grass carp are inexpensive compared to some other control methods and offer long-term control, but fish may need to be restocked at intervals.
- Grass carp offer a biological alternative to aquatic plant control.

Disadvantages

- Depending on plant densities and types, it may take several years to achieve plant control using grass carp and in many cases control may not occur.
- If the waterbody is overstocked, all submersed aquatic plants may be eliminated. Removing excess fish is difficult and expensive.
- The type of plants grass carp prefer may also be those most important for habitat and for waterfowl food.
- If not enough fish are stocked, less-favored plants, such as Eurasian milfoil, may take over the lake.
- Stocking grass carp may lead to algae blooms.
- All inlets and outlets to the lake or pond must be screened to prevent grass carp from escaping into streams, rivers, or other lakes.

Permits

Stocking grass carp requires a fish-stocking permit from the Washington Department of Fish and Wildlife. Also, if inlets or outlets need to be screened, an Hydraulic Project Approval application must be completed for the screening project.

Costs

In quantities of 10,000 or more, 8 to 12 inch sterile grass carp can be purchased for about $5.00 each for truck delivery. The cost of small air freighted orders will vary and is estimated at $8 to $10 per fish.

The costs for researchers to locate, culture, and test bio-control agents is high. Once approved for use, insects can sell for $1.00 or more per insect. Sometimes it is possible to establish nurseries where weed specialists can collect insects for reestablishment elsewhere.

Other Considerations

- Would not achieve immediate results – takes time and is not guaranteed to work.
- Community may have concerns with introduced species
- Potential damage to the native plant community of the lake, which could result in the establishment of other aggressive plant species as pioneers
- Concerns from fishermen about grass carp
- Initial investment very expensive
- The introduction of grass carp has generally been discouraged by State agencies, especially in systems like Spring Lake.

Suitability for Spring Lake

- Grass carp are not suitable for aquatic plant control in Spring Lake. The infestation of milfoil has not reached a level where a bio-control such as grass carp would be necessary.
- Their preferred food species include the dominant submersed aquatic species in Spring Lake, which might be grazed before the milfoil. They could remove all the beneficial plants that support a healthy fish population. Without cover and the invertebrates associated with beneficial native aquatic vegetation, the system would be degraded and some species (invertebrates, fish, etc.) may be extirpated.
- The lake also has an outlet stream that eventually flows into another lake, Peterson Lake, making it much more difficult to obtain the permits necessary to stock grass carp.

Watermilfoil Weevil

The following information and citations on the watermilfoil weevil are taken from the Washington State Department of Ecology's website on Aquatic Plant Management. http://www.ecy.wa.gov/programs/wq/plants/management/weevil.html

The milfoil weevil, *Euhrychiopsis lecontei*, has been associated with declines of Eurasian watermilfoil (*Myriophyllum spicatum*) in the United States (e.g. Illinois, Minnesota, Vermont, and Wisconsin). Researchers in Vermont found that the milfoil weevil can negatively impact Eurasian watermilfoil by suppressing the plants growth and reducing its buoyancy (Creed and Sheldon 1995). In 1989, state biologists reported that Eurasian watermilfoil in Brownington Pond, Vermont had declined from approximately 10 hectares (in 1986) to less than 0.5 hectares. Researchers from Middlebury College, Vermont hypothesized that the milfoil weevil, which was present in Brownington Pond, played a role in reducing Eurasian watermilfoil (Creed and Sheldon 1995). During 1990 through 1992, researchers monitored the populations of Eurasian watermilfoil and the milfoil weevil in Brownington Pond. They found that by 1991 Eurasian watermilfoil cover had increased to approximately 2.5 hectares (approximately 55-65 g/m^2) and then decreased to about 1 hectare (<15 g/m^2) in 1992. Weevil abundance began increasing in 1990 and peaked in June of 1992, where 3 – 4 weevils (adults and larvae) per stem were detected (Creed and Sheldon 1995). These results supported the hypothesis that the milfoil weevil played a role in reducing Eurasian watermilfoil in Brownington Pond.

Another documented example where a crash of Eurasian watermilfoil has been attributed to the milfoil weevil is in Cenaiko Lake, Minnesota. Researchers from the University of Minnesota reported a decline in the density of Eurasian watermilfoil from 123 g/m^2 in July of 1996 to 14 g/m^2 in September of 1996. Eurasian watermilfoil remained below 5 g/m^2 in 1997, then increased to 44 g/m^2 in June and July of 1998 and declined again to 12 g/m^2 in September of 1998 (Newman and Biesboer, in press). In contrast, researchers found that weevil abundance in Cenaiko Lake was 1.6 weevils (adults and larvae) per stem in July of 1996. Weevil abundance, however, decreased with declining densities of Eurasian watermilfoil in 1996 and by September 1997 weevils were undetectable. In September of 1998 weevil abundance had increased to >2 weevils per stem (Newman and Biesboer, in press). Based on observations made by researchers in Vermont, Ohio and Wisconsin it seems that having 2 weevils (or more) per stem is adequate to control Eurasian watermilfoil. However, as indicated by the study conducted in Cenaiko Lake, Minnesota, an abundance of 1.5 weevils per stem may be sufficient in some cases (Newman and Biesboer, in press).

In Washington State, the milfoil weevil is present primarily in eastern Washington and occurs on both Eurasian and northern watermilfoil (*M. sibiricum*), the latter plant being native to the state (Tamayo et. Al. 1999). During the summer of 1999, researchers from the University of Washington determined the abundance of the milfoil weevil in 11 lakes in Washington. They found, that weevil abundance ranged from undetectable levels to 0.3 weevils (adults and larvae) per stem. Fan Lake, Pend Oreille County had the greatest density per stem of 0.6 weevils (adults, larvae and eggs per stem). The weevils were present on northern watermilfoil. These abundance results are well below the recommendations made by other researchers in Minnesota, Ohio, Vermont, and

Wisconsin of having at least 1.5 – 2.0 weevils per stem in order to control Eurasian watermilfoil.

To date, there have not been any documented declines of Eurasian watermilfoil in Washington State that can be attributed to the milfoil weevil, although Creed speculated that declines of Eurasian watermilfoil in Lake Osoyoos and the Okanogan River may have been caused by the milfoil weevil. In Minnesota, Cenaiko Lake is the only lake in that state that has had a Eurasian watermilfoil crash due to the weevil; other weevil lakes are yet to show declines in Eurasian watermilfoil.

Researchers in Minnesota have suggested that sunfish predation may be limiting weevil densities in some lakes (Sutter and Newman 1997). The latter may be true for Washington State, as sunfish populations are present in many lakes in the state, including those with weevils. In addition, other environmental factors that may be keeping weevil populations in check in Washington, but have yet to be studied, include over-wintering survival and habitat quality and quantity (Jester et. Al. 1997; Tamayo et. Al., in press). Although the milfoil weevil shows potential as a biological control for Eurasian watermilfoil more work is needed to determine which factors limit weevil densities and what lakes are suitable candidates for weevil treatments in order to implement a cost and control effective program.

Advantages

- Milfoil weevils offer a biological alternative to aquatic plant control.
- They may be cheaper than other control strategies.
- Biocontrols enable weed control in hard-to-access areas and can become self-supporting in some systems.
- If they are capable of reaching a critical mass, biocontrols can decimate a weed population.

Disadvantages

- There are many uncertainties as to the effectiveness of this biocontrol in western Washington waters.
- There have not been any documented declines of Eurasian watermilfoil in Washington State that can be attributed to the milfoil weevil.
- Many of our lakes, including Spring Lake, have introduced sunfish populations that may predate on the milfoil weevils.
- Bio-controls often don’t eradicate the target plant species, and there would be population fluctuations as the milfoil and weevil follow predator-prey cycles.

Permits

The milfoil weevil is native to Washington and is present in a number of lakes and rivers. It is found associated with both native northern milfoil and Eurasian watermilfoil. A company is selling milfoil weevils commercially. However, to import these out-of-state weevils into Washington requires a permit from the Washington Department of Agriculture. As of October 1, 2002 no permits have been issued for Washington.

Suitability for Spring Lake

- Since the milfoil weevil is a new bio-control agent, it has not been released yet intentionally in western Washington to control Eurasian watermilfoil. It is uncertain how effective the weevil will be and whether populations per stem can be maintained at levels high enough to eradicate Eurasian watermilfoil.
- Also, as with the grass carp, the infestation of milfoil in Spring Lake is not heavy enough to warrant bio-control introduction when other methods are still available.

ROTOVATION, HARVESTING, AND CUTTING

Rotovation

Rotovators use underwater rototiller-like blades to uproot Eurasian watermilfoil plants. The rotating blades churn seven to nine inches deep into the lake or river bottom to dislodge plant root crowns that are generally buoyant. The plants and roots may then be removed from the water using a weed rake attachment to the rototiller head or by harvester or manual collection.

Harvesting

Mechanical harvesters are large machines which both cut and collect aquatic plants. Cut plants are removed from the water by a conveyor belt system and stored on the harvester until disposal. A barge may be stationed near the harvesting site for temporary plant storage or the harvester carries the cut weeds to shore. The shore station equipment is usually a shore conveyor that mates to the harvester and lifts the cut plants into a dump truck. Harvested weeds are disposed of in landfills, used as compost, or in reclaiming spent gravel pits or similar sites.

Cutting

Mechanical weed cutters cut aquatic plants several feet below the water's surface. Unlike harvesting, cut plants are not collected while the machinery operates.

Suitability for Spring Lake

None of these options are suitable for the level of infestation at Spring Lake. They are not eradication tools, but rather are used to manage and control heavy, widespread infestations of aquatic weeds. These processes create plant fragments, and therefore should not be used in systems where milfoil is not already widespread. In a moderate infestation such as Spring Lake, these methods would probably serve to spread and expand the infestation. According to Ecology, "There is little or no reduction in plant density with mechanical harvesting." Since the aim of this project is to eliminate milfoil from the system, these are not compatible control strategies. Harvesting and cutting do not remove root systems. Rotovation would cause damage to the lake sediments and associated animals in a system that does not already receive dredging for navigability.

Drawdown

Lowering the water level of a lake or reservoir can have a dramatic impact on some aquatic weed problems. Water level drawdown can be used where there is a water control structure that allows the managers of lakes or reservoirs to drop the water level in the waterbody for extended periods of time. Water level drawdown often occurs regularly in reservoirs for power generation, flood control, or irrigation; a side benefit being the control of some aquatic plant species. However, regular drawdowns can also make it difficult to establish native aquatic plants for fish, wildlife, and waterfowl habitat in some reservoirs.

Suitability for Spring Lake

Drawdown is not a viable control strategy for Spring Lake. The outlet from Spring Lake is a natural stream through a wetland system that does not have a control structure installed. Not only would drawdown be difficult to achieve, it would also cause significant damage to the ecosystem. The amount of drawdown required to impact milfoil would dry out the littoral zone of the lake. This would damage native plants and animals in both the lake and the adjacent wetland and have many negative consequences for residents living around the lake. Without a surface inflow to the system, returning the water level to a previous state would be both cost and time prohibitive.

NUTRIENT REDUCTION

Nutrient Reduction Alternative

At lakes in watersheds with identifiable sources of excess nutrients, a program to reduce nutrients entering the lake could possibly be an effective method of controlling aquatic vegetation. Sources of excessive nutrients might include failing septic tanks, other accidental or planned wastewater effluent, or runoff from agricultural lands. If nutrient reduction were enacted as the primary method of weed control, extensive research would be necessary to determine the current nutrient budget for the lake and surrounding watershed, whether nutrient reduction would result in milfoil reduction, and to identify and mitigate the natural and human-mediated nutrient sources.

Suitability for Spring Lake

Nutrient reduction is not an appropriate control measure for Spring Lake for several reasons. First, there are few identified sources of high nutrient input. The rate of septic tank failure was estimated to be 11.5%, only slightly above the 8.8% average for the entire Cedar River Basin Planning area. (King County, 1993) While there are a number of small noncommercial farms in the Peterson Creek subbasin that have the potential to contribute nutrients to the system, stormwater samples taken at the mouth of Peterson Creek do not indicate current septic or agricultural nonpoint pollution problems. Conditions reported in 1993 are very similar to current conditions in the Peterson Creek subbasin, due in part to wetland catchments within the subbasin being designated as Wetland Management Areas in the Cedar River Basin Plan (A. Biklé, pers. comm. 2003).

Second, recent water quality data collected through the King County Lake Stewardship Program's volunteer monitoring program, (Tables 1 and 4), do not show phosphorus and nitrogen levels to be inordinately high (King County, 2003).

And finally, nutrient reduction measures are not likely to be an effective control on milfoil. Milfoil has the ability to live in various environmental conditions; it can withstand a broad range of aquatic environments, from oligotrophic to eutrophic waters, and it grows in water depths from as shallow as 0.5 meters to as deep as 8 meters. It also can grow in substrates ranging from poor, sandy sediment to highly organic soils and can survive in wide ranges of salinity, pH, and temperature conditions (Aiken et al., 1979; Nichols and Shaw, 1986; Smith Barko, 1990, as cited in Sheldon and Creed, 1995).

Neither the data from the *Cedar River Current and Future Conditions Report,* nor the water quality data from the King County volunteer monitoring program (Tables 1 and 4), suggest a need to reduce significantly the external nutrient loads to Spring Lake.

While water quality improvements would likely result if each watershed resident reduced or eliminated sources of nutrient input to the lake, this would not be likely to be an effective primary method of controlling aquatic weeds. Nutrients in the sediments would be more likely to have an impact, since milfoil and other targeted aquatic weed species obtain more than 85% of their nutrients from the sediment (Jonathan Frodge, pers. comm. 2003). Such an effort would be beyond the scope of any project that could be undertaken at Spring Lake.

Table 4: Recent Spring Lake Water Quality data
From the King County Volunteer Monitoring Program

Date	Secchi Depth (m)	Chl-a (ug/l)	Total Phosphorus (ug/l)	Total Nitrogen (ug/l)
30-Apr-00	2.3	3.00	12.4	752
14-May-00	2.0	2.20	10.8	674
29-May-00	2.3	7.10	13.6	572
11-Jun-00	2.3	7.30	12.0	510
25-Jun-00	2.0	5.60	10.5	431
9-Jul-00	2.0	6.90	9.8	381
23-Jul-00	2.3	3.10	7.8	360
6-Aug-00	2.8	1.60	6.1	334
20-Aug-00	2.5	1.90	8.1	370
4-Sep-00	2.8	2.20	9.7	415
1 oct oo	3.0	3.80	13.6	355
15-Oct-00	2.5	7.60	10.6	311
6-May-01	2.0	6.6	11.9	469
20-May-01	2.8	5.25	11.1	409
3-Jun-01*	2.5	6.57	64.1	358
17-Jun-01	2.0	4.95	16.3	364
1-Jul-01	2.3	3.4	8.7	353
15-Jul-01	2.8	3.16	9.1	350
29-Jul-01	2.5	3.42	5.2	345
12-Aug-01	2.5	1.54	6.5	355
26-Aug-01	3.0	2.79	7.5	370
9-Sep-01	3.0	1.74	10.2	378
23-Sep-01	3.3	1.86	8.8	313
7-Oct-01	3.0	3.16	11.4	361
21-Oct-01	2.8	5.51	10.8	348
21-Apr-02	2.0	4.49	13.8	708
5-May-02	2.0	2.36	27.9	761
19-May-02	1.8	3.36	9.9	605
2-Jun-02	1.8	5.44	12.1	535
16-Jun-02	1.8	5.93	11.7	498
30-Jun-02	2.0	5.85	13.1	365
15-Jul-02	2.4	4.61	10.9	371
28-Jul-02	2.8	3.36	8.7	376
11-Aug-02	2.3	3.20	6.8	352
25-Aug-02	3.3	3.36	12.3	390
8-Sep-02	4.0	3.89	18.5	452
22-Sep-02	3.3	2.40	8.9	342
6-Oct-02	3.8	2.85	11.6	296
20-Oct-02	3.3	5.16	11.3	335
Mean	**2.6**	**4.06**	**12.4**	**426**
Max	**4.0**	**7.60**	**64.1**	**761**
Min	**1.8**	**1.54**	**5.2**	**296**

* TP values unusually high for most lakes in program on 3-Jun-01; possible laboratory error.

NO ACTION ALTERNATIVE

One option for managing aquatic weeds in Spring Lake is to let aquatic weeds continue to grow, and do nothing to control them. This "no action" alternative would acknowledge the presence of the aquatic weeds but would not outline any management plan or enact any planned control efforts. Effectively, a no action determination would preclude any integrated treatment and/or control effort, placing the choice and responsibility of aquatic weed control with lakefront property owners.

Suitability for Spring Lake

The milfoil infestation is currently moderate in density; unless control measures are enacted, it is likely to increase each growing season in the future until the entire littoral zone of the lake is dominated by milfoil. Based on results of informal surveys by residents and King County staff, the infestations of milfoil, purple loosestrife, and fragrant water lily have greatly increased since the last comprehensive plant survey in 1994 (King County, 1996). If there is no control effort, it is likely that weed infestations will continue to grow, making Spring Lake a prime source of milfoil fragments for other nearby lakes with public access and boat launch facilities, as well as a potential source of seed spread by purple loosestrife. Even if some of the residents chose to control the aquatic weeds near their properties, pockets of milfoil would remain. The surviving plants would fragment each autumn, spreading to other areas of the lake, including those that were treated by residents. The no action alternative is not preferred by members of the Spring Lake community, or the King County Department of Natural Resources and Parks.

INTEGRATED TREATMENT PLAN

Spring Lake and its associated shoreline contain four listed noxious weed species that should have control measures implemented to halt the spread of their invasions and reverse the degradation currently occurring. The four target species are the Eurasian watermilfoil (*Myriophyllum spicatum*), fragrant water lily (*Nymphaea odorata*), purple loosestrife (*Lythrum salicaria*), and yellow flag iris (*Iris pseudacorus*). Although all four species at Spring Lake are highly aggressive and are difficult to control/eradicate, we believe that the goal of eradication is reasonable for all of them, and we can be successful within the time frame of the project.

Eurasian watermilfoil (*Myriophyllum spicatum*)

Initial control of Eurasian watermilfoil will be accomplished using an aquatic formulation of 2,4-D (DMA*4IVM®, Aquakleen® or Navigate®) in late May to early June over approximately 12 acres of milfoil-infested area as found in surveys for the King County Regional Milfoil Plan. The contractor surveys the entire lake with divers using a GPS and marking all the points that need treatment. The areas are marked on the water's surface with buoys and then the application is performed from a boat using trailing hoses to disperse the herbicide underwater. Due to the nature of the sediments in Spring Lake (as described in Aquatic Plant Control Alternatives), 2,4-D DMA is the preferred formulation. Eradication of Eurasian watermilfoil is the end goal. A follow-up application in Year 1, about three weeks after the first will aim to pick up missed plants or late emergents. We will plan for a maximum of 25% of the original area of 12 acres to need the second treatment. Diver hand-pulling (or diver dredging) will clean up any remaining milfoil found after both herbicide applications have had time to take effect (i.e. two to three weeks after the second herbicide treatment).

We will be installing a bottom barrier at the boat launch in the winter of Year 1 to ensure eradication in the vicinity, and to aid in preventing new introductions. We will continue community education efforts, including training in milfoil identification and survey methods. There will also be an increase in the signage at the boat launch.

The NPDES permit coverage from WSDA requires notification and posting of the waterbody, and these specific protocols will be followed. The NPDES permit also requires monitoring of the herbicide levels in the lake after treatment. Independent samples will be collected at the time of the application and again five days post treatment. A baseline sample will also be taken <u>before</u> the application, since Water Quality experts at Ecology report heightened levels of 2,4-D in our surface waters due to runoff after heavy storm events (K. Hamel, pers. comm.) One sample is taken from within the treatment area, and one from outside. These four samples (per application) will be sent to an independent, Ecology-accredited laboratory for the analysis. As more of these samples need to be analyzed to meet NPDES requirements, some companies may get an ELIZA test accredited through Ecology which will be less expensive. As the permit stands in 2003, this procedure will be performed each year an application for milfoil is conducted. Surveys after the initial application are essential to determining the success of the effort, and will be used to determine what measures need to be implemented to complete the milfoil control for Year 1 (and subsequent years).

Problems may arise if the same firm that conducted the herbicide application also surveys for the success of the effort. We plan to hire a separate, independent firm to conduct these surveys to overcome this potential problem. Volunteers from the Spring Lake community will be directly involved with overseeing the implementation of control work to keep the contractors accountable.

Year 2 will begin with diver surveys of the lake to check the status of the infestation. Spot herbicide treatment with 2,4-D (DMA*4IVM®, Aquakleen® or Navigate®) will begin in late May to early June over an estimated maximum of 50% of the original milfoil infested area (max. six acres). Obviously, if the diver surveys find greater than six acres need to be treated, the real infestation size will be accommodated. At this point we will have a sense as to whether the 2,4-D has eliminated a significant amount of the Eurasian watermilfoil, or whether it has seemed to become less effective. By late summer 2004, Triclopyr (Garlon 3A) should be fully approved for aquatic use by U.S. EPA and by the State of Washington. We may a shift from 2,4-D to Triclopyr if we find that the milfoil has build up an herbicide resistance.

After the first herbicide application in Year 2, we will conduct the first diver hand-pulling/ diver dredging about three to four weeks after the herbicide treatment. We plan for a maximum of 25% of the original area (or three acres) to need the first manual removal. We will follow this with a second hand-pulling/diver dredging in late August as needed. At this point, we hope that less than 10% of the original area (or one acre) will be involved. Annual maintenance of the bottom barrier at the boat launch will consist of removal of rooted plants and sediment accumulations, as well as securing the barrier to the bottom to ensure safety and effectiveness. Continued community education will complete our Eurasian watermilfoil efforts for Year 2 (see Continuing Community Education, p. 10).

Year 3 will again begin with diver surveys of the lake to assess the milfoil distribution. If herbicide is needed, and the 2,4-D has been effective and we have not found the need to switch to Triclopyr, we will stay with the original active ingredient for the herbicide treatment in Year 3. However, if we have seen signs of herbicide resistance and the Triclopyr application from Year 2 was completed and was effective, we will use Triclopyr to initiate our control program for Year 3. We project that no more than an acre total of Eurasian watermilfoil will need this treatment. We will then use diver hand-pulling/ diver dredging as necessary if individual plants are discovered in our mid-summer survey. Annual maintenance of the bottom barrier at the boat launch and continued community education will complete our Eurasian watermilfoil efforts for Year 3.

In Years 4-7 (and beyond), diver and surface surveys will occur at least twice during the growing season. Because permits for herbicide applications must be acquired far in advance, we plan to rely on diver hand-pulling as the control method. If at any point we find that we are losing ground on eradication efforts, we will apply for the appropriate permits and perform spot applications with either 2,4-D (or Triclopyr) based on cost-benefit analysis. We will need to continue the bottom barrier maintenance annually.

There should be no need to revegetate the areas of Eurasian watermilfoil after treatment. Most of the native submersed species are monocots (*Potamogeton* sp.) that should be relatively unaffected by either the 2,4-D (or Triclopyr) application. Removing the noxious invaders will halt the degradation of the system and allow the dynamic natural equilibrium to be maintained.

Eurasian watermilfoil (*Myriophyllum spicatum)* should be eliminated by this outlined integrated approach. Two herbicide applications per season in the first year(s), followed by manual methods, should ensure that no milfoil plants survive. Once the established plants are eradicated, and follow up surveys have verified their absence for several seasons, potential reintroduction will be a remaining challenge. Any areas that dewater will be checked for milfoil seedlings. Since Spring Lake does not currently have prolific plant growth, milfoil plants should be found easily and manual control methods should prove more effective than in a lake with dense beds of native vegetation.

Fragrant water lily (*Nymphaea odorata)*

Control efforts on the fragrant water lily will begin in the mid-summer of Year 1. The intensity of control will be equal across the entire lake, with eradication as the end goal. The 2,4-D application for the milfoil might have some effect on the fragrant water lily, since it is also a broad-leafed plant and there is some overlap in the distribution of these plants in Spring Lake. However, 2,4-D is reported as not being very effective on this species (K. Hamel, pers. comm.). At the same time as the second herbicide application for the Eurasian watermilfoil in Year 1, we will use Glyphosate (Rodeo® or Aquamaster®) on the fragrant water lilies around the lake. In addition to posting requirements, the NPDES permit requires monitoring of the glyphosate levels in the lake after treatment. Independent samples will be collected about one hour after the application and again 24 hours post treatment. One sample is taken from within the treatment area, and one from outside. These four samples (per application) will be sent to an independent, Ecology-accredited laboratory for the analysis.

Year 2 will undoubtedly include another Glyphosate application. Since the milfoil will be receiving an herbicide treatment, we may again get some control on the water lily from the 2,4-D. However, since the 2,4-D will be applied in spot applications, there may less and less overlap between the milfoil and fragrant water lily. In either case, a Glyphosate application will be performed when floating leaves have formed on the water lily (approximately the same time as Year 1). One Glyphosate application is planned in Year 2 and will be followed by cutting and removing any plants not killed by the herbicide. This manual control will be performed by the end of the summer before the plants set seed.

In future years, we may need to eliminate returning plants or new infestations. We have planned for a "final" herbicide application in Year 3 as a contingency. Cutting will be used to control small areas of water lily. If the level of water lily infestation again gets to the point where manual control is no longer feasible, we will plan for an herbicide application the following summer. This lead-time is required to get the necessary permits. The native water lily (*Nuphar luteum*) is well represented in the south end of the lake where much of the fragrant water lily is currently found and is likely to expand its distribution. The selective nature of spot applications of Glyphosate should minimize impacts to non-target vegetation, and may allow the native water lily to rebound or expand.

Purple loosestrife (*Lythrum salicaria)*

Control efforts on purple loosestrife will begin on the shoreline along the fen and rest of the Class 1 wetland because of its fragile nature. This is the area south of the boat launch and on both sides of the outlet channel to Tributary 0328. Secondly, we will focus on parcels that have remnant patches of wetland vegetation. Finally, we will work with the rest of the residential parcels with purple loosestrife on their shoreline. We will secure permission from all of the individual landowners before any work proceeds on their land.

One Glyphosate application per year is planned for Years 1-3. Plants will be rechecked 1 month after herbicide application, and any that have produced flowers will be manually controlled before they set seed. These plants will be cut at the base and disposed of as garbage. Since these purple loosestrife plants are mainly along the shoreline in wetland areas with a dense concentration of native plants, there should be no need to revegetate in LCR28.

Guidance will be provided to residential landowners as to native plants or non-aggressive exotics that would serve well to perform the desired functions of buffer vegetation along their shorelines. Some landowners are concerned with aesthetic elements and would like to replace the beautiful floral display of purple loosestrife, whereas others have ecological concerns about buffering a waterbody with wetland vegetation to help maintain the health of the system. Part of the community education process will be bringing these two different views together to establish more natural landscapes on the residential parcels around the lake, and develop sustainable, noxious-weed-free systems. Purple loosestrife has decreased slightly due to four years of manual control methods, especially along the lake edge of the fen.

Yellow flag iris (*Iris pseudacorus)*

Control efforts on the yellow flag iris will focus initially on just the lakeshore along the fen and Class 1 wetland area. We plan to use a treatment with glyphosate (Rodeo® or Aquamaster®), which should be done at the same time as the purple loosestrife and fragrant water lily control. We would make one herbicide application in each of the first 3 years, restricting these efforts to the shoreline along LCR 28.

Control efforts around the remainder of the lake will be accomplished through educational outreach. We will begin by asking residents to continue taking seed heads off the plants in late summer before they expand the infestation. We will also encourage landowners to start digging out the individual plants on their shoreline. Permission from all of the individual landowners will be necessary before any herbicide work can proceed on their land. These efforts will be ongoing. Since these yellow flag iris plants are mainly along the shoreline in wetland areas with a dense concentration of native plants, there should be no need to revegetate in LCR28. Suggestions will be provided to residential landowners as to native plants or non-aggressive exotics that would serve well to perform the desired functions of buffer vegetation along their shorelines.

Lesser cattail *(Typha angustifolia)*

The infestation of *Typha angustifolia*, a Monitor Species on the Washington State Noxious Weed List, is still in the pioneering stage at Spring Lake. There appears to be just one, discrete stand on the southeastern shoreline. This infestation will be surveyed and recorded with GPS to determine its scope and how many properties are involved. The property owners will be notified about the weed's presence and its potential negative impacts on our native vegetation. The Spring Lake Community Club will work with these landowners to encourage the control/eradication of this infestation through manual, mechanical or chemical means. This species will become part of our plant identification workshops so residents may identify any other pockets on the lake during our annual surveys for the four other target noxious weeds. Herbarium samples will be taken for the

King County Noxious Weed Control Program, Lake Stewardship Program, and the University of Washington Herbarium.

PLAN ELEMENTS, COSTS, AND FUNDING

Table 5 outlines the tasks and estimated costs of implementation on an annual basis. Implementation of the Spring Lake IAVMP will span at least seven years, at a total estimated cost of $86,716. The majority of the costs accrue in the first several years, which is the period of most aggressive treatment. Beyond that, costs are directed at detecting and controlling re-introduction of noxious aquatic plant species.

Table 5. Spring Lake Milfoil Project Budget

Task	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	7 Yr Total
Herbicide-milfoil	$9,759	$3,900						**$13,659**
Herbicide - water lily	$1,000	$750	$750					**$2,500**
Herbicide-Loosestrife	$750	$750	$500					**$2,000**
Herbicide-Yellow Iris	$750	$750	$500					**$2,000**
Herbicide Application Permit	$2,000	$2,000	$1,000					**$5,000**
Post-treatment monitoring	$1,200	$600	$600					**$2,400**
Diver Survey	$1,600	$1,600	$1,600	$1,600	$1,600	$800	$800	**$9,600**
Diver Hand Pull/Diver Dredge	$7,680	$10,240	$1,280	$1,280	$1,280	$640	$640	**$23,040**
Boatlaunch Bottom Barrier	$1,250	$215	$215	$215	$215	$215	$215	**$2,540**
Education and Outreach	$1,500	$1,500	$750	$750	$500	$500	$500	**$6,000**
Printing Costs	$2,000	$250	$250	$250				**$2,750**
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	7 Year Total
Totals	**$ 29,489**	**$22,555**	**$7,445**	**$4,095**	**$3,595**	**$2,155**	**$2,155**	**$71,489**

8.8% tax	$ 6,291.03
12.5% contingency	$ 8,936.13
Project Total	**$ 86,716.16**

Sources of Funding

There are several likely sources of funding available for project implementation:

Grants

The Washington State Department of Ecology has an Aquatic Weeds Management Fund (AWMF). This IAVMP was developed to be consistent with all AWMF guidelines and requirements. Given the relatively low-level infestation, outstanding ecological value of Spring Lake and its watershed, and the potential for infestation of neighboring lakes, it is hoped that Ecology and other grant programs will offer funding. Other possible funding sources include King County's WaterWorks and the Natural Resources Stewardship Network.

Dedicated non-grant funds from King County

The King County Noxious Weed Program has limited funds available to contribute to weed control projects. While this can not be considered an ongoing source of funding, $1000 is promised to the project in the first year of implementation.

Community-Based Funding

There is a proposal before the Spring Lake Community Club to raise annual dues by $10 or more, with the additional revenue to be dedicated to projects and programs designed to improve lake and watershed conditions. This could generate several thousand dollars over the first five years of the project. Noxious aquatic weed management currently tops the list of threats to the lake.

If funds raised by increasing Community Club dues prove insufficient, community members have discussed forming a Lake Management District. If implemented, a LMD would collect an annual fee from all watershed property owners. Fees would be weighted based on property size and proximity to the lake. Money collected through a LMD must be dedicated to addressing specific problems facing the lake and watershed. This IAVMP will provide some guidance should watershed residents choose to pursue a LMD.

Although not yet researched, one community member offered the idea of purchasing a community bond, the interest of which could be used to fund lake and watershed improvement projects.

Matching Funds

Table 6 shows the matching requirements outlined by Ecology's AWMF and the estimated in-kind match and cash match provided by King county and the Spring Lake Community.

Table 6. Total Matching Funds

Toal Project cost =	$ 86,716.16			
		Amt. over required match	**Budgeted**	**% of Total**
75% of total project	$ 65,037.12			
Required in-kind match	$ 10,839.52	$735.48	$11,575.00	13.3%
Required cash match	$ 10,839.52	$4,004.08	$14,843.60	17.1%
		Ecology $ after match	**$60,297.56**	69.5%

Table 7. In-kind Matching Funds

Item	Cost	Units	Units/ year	Years	Notes	Total
Volunteer hours	$ 12.50	per hour	140	5	12-15 very active community members. ~10 certified divers on lake. Time estimates include boat surveys, diver training, bottom barrier maintenance, steering committee meetings,ID workshops, educational flyer development.	$ 8,750.00
Educational Materials Development and Presentation	$ 250.00	per year	1	5	Community member time spent developing materials and presenting materials to youth groups and other organizations	$ 1,250.00
Website	$ 75.00	per year	1	5	Estimated ISP charges. Development and content update time included in volunteer hours.	$ 375.00
Boat rental	$ 40.00	per day	6	5		$ 1,200.00
					Total est. in-kind match	**$ 11,575.00**

Table 8. Cash Matching Funds

Item	Cost	Units	Units/ year	Years	Notes	Total
Community self-tax	$ 500.00	per year	1	5	Based on implementation of one or more community-based funding strategies outlined in IAVMP. Will be assessed annually into future (indefinitely).	$ 2,500.00
KC DNRP Noxious Weed Control Program Cost Share	$ 1,000.00	per year	1	1	Dedicated cost share funds from Noxious Weed Control Program	$ 1,000.00
Grants	$ 1,500.00	per year	1	2	Estimate based on likely sources.	$ 3,000.00
KC Staff - Environmental Scientist	$ 38.75	per hour	40	3	See below for salary and burden rates as of 2002.	$ 4,650.00
KC Staff - Aquatic Noxious Weed Specialist	$ 30.78	per hour	40	3		$ 3,693.60
					Total est. cash match	**$ 14,843.60**

Table 9. KC Staff Salary and Burden Rates

Position	Hourly Rate	Benefits - 33%	Paid Time Off - 15%	Overhead - 25% (State allowed rate)	Hourly Burdened Rate
Environmental Scientist	$ 22.40	$ 7.39	$ 3.36	$ 5.60	**$38.75**
Aquatic Weeds Specialist	$ 17.79	$ 5.87	$ 2.67	$ 4.45	**$30.78**

IMPLEMENTATION AND EVALUATION

The implementation of the plan will follow the process outlined below:

1. **Convene a project Implementation Committee.** Many Steering Committee members have indicated their willingness to transition into this role.
2. **Review proposed plan and develop timeline with specific tasks.** The IAVMP will guide this process.
3. **Assign tasks to Implementation Committee members.**
4. **Issue a Request for Proposals for weed survey and control work.**
5. **Secure necessary permits.** Permit application will be coordinated with the contracted applicator.
6. **Implement community education plan.**
7. **Apply herbicide treatment.** Application will be completed as prescribed in IAVMP, unless consultation with Ecology and the applicator leads to defensible changes in the plan.
8. **Conduct follow-up surveys**. Professional contractors and community members who have received adequate training can complete this work, with community participation under supervision of King County staff.
9. **Apply follow-up herbicide treatment if necessary.** Follow-up surveys will determine the extent to which this work is necessary.
10. **Conduct diver surveys and hand-pulling as necessary.** Professional contractors and community members who have received adequate training can complete this work, with community participation under supervision of King County staff.

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